MOVEMENT ABC

AN ANNOTATED BIBLIOGRAPHY

AN ANNOTATED BIBLIOGRAPHY OF STUDIES USING THE TOMI/MOVEMENT ABC: 1984-1996.

Anna L. Barnett
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Introduction

Background

The *Movement Assessment Battery for Children,* henceforth *Movement ABC,* was published in 1992 (Henderson and Sugden, 1992). At the time of writing (late 1997), the battery has been translated into five European languages, Danish, Dutch, Finnish, Italian and Swedish. Chinese and Japanese translations are currently in preparation. In contrast to its precursor, the *Test of Motor Impairment* (Stott, Moyes and Henderson, 1984), the *Movement ABC* contains three components. In addition to a completely revised version of the standardized **Test**, a teachers' **Checklist** and a set of **Guidelines for Intervention** are provided for the first time.

The two assessment components of the *Movement ABC* have very different origins. The motivation for the development of the standardized **Test** was the founding author Denis Stott's interest in the hypothesis that perinatal trauma of various kinds were linked to motor and other learning difficulties in later childhood. Hampered, in the 1960s, by the absence of a reliable *research* instrument which would provide an objective basis for the detection and quantification of motor dysfunction in children of school age, Stott set about the development of an appropriate instrument while working at the University of Glasgow. This came to fruition in 1972 as the *Test of Motor Impairment* or *TOMI* (Stott, Moyes & Henderson, 1972). Some ten years later, Henderson undertook a radical revision of the *TOMI* (Henderson Revision; Stott, Moyes and Henderson, 1984). The motivation for this revision was the idea that the test could be made to yield much more data of relevance to practitioners than hitherto. To achieve this objective, the content of the test was reorganized and a new dimension introduced which allowed the assessor to supplement the quantitative data obtained on the child's performance with a record of *how* he/she performed the test tasks. Also, new normative data was collected in both the U.K. and Canada.

The *Movement ABC* **Checklist** also has a long history. At the same time as the first edition of the *TOMI* was appearing, David Sugden, then working at the University of California, Los Angeles with Professor Jack Keogh, had just developed a teachers' checklist aimed at the identification of children with movement difficulties in the classroom context (Sugden, 1972). As a specialist in both physical and special education, Sugden's primary concern then was to alert teachers to the broader educational significance of such difficulties. At a much later date Sugden and Sugden (1991) produced a refined version of the checklist developed in the U.K.

With the retirement of their original collaborators, Henderson and Sugden both found themselves taking stock of their interests in assessment. The complementary nature of the instruments developed by the two groups, together with Henderson and Sugden's shared perspective on the area and good working relationship pointed the way forward to the *Movement ABC*. By bringing their respective assessments together into one package, they were able to offer practitioners two complementary modes of assessment which they could use separately or together as appropriate. In addition, by building upon the ideas they had developed from working with such children they produced a set of guidelines for intervention. Henderson and Sugden were then able to offer users a scheme which begins with the identification of the child with movement difficulties and proceeds all the way to a plan for improvement. For readers who are not familiar with the three elements of the battery, a very brief outline of each one is offered in the following pages.

The Standardized Test

The standardized **Test** in the *Movement ABC* is designed for use with children aged four to twelve+ years. There are four age bands, each with eight items. These start with a set of simple items to be used with children aged four to six and end with more difficult tasks for children aged eleven plus.

Although the difficulty level of the tasks vary with age, each child performs:

- three activities requiring manual dexterity (one uni-manual task in which the speed and accuracy of the preferred and then the non-preferred hand are tested separately, one bi-manual task, which also demands speed and accuracy and one task in which the dominant hand must be used in a careful and controlled manner).
- two tasks requiring ball skill (one to receive and one to project).
- three balance tasks (one focusing on static and two on dynamic balance; the dynamic tasks require the child to be able to perform both fast explosive and slow controlled movements).

Since the primary focus of the test is on the objective assessment of movement **difficulties** in children, all tasks have been carefully selected to be easy for most children in a designated age band. This allows for fine discriminations in performance at the lower end of the scale but does not offer differentiation at the other end. A child's performance on the test is recorded in several ways. Raw scores, such as the number of seconds taken to complete a task, are noted and can be used for certain purposes. More commonly, however, raw scores are converted into scaled scores in order to ascertain where the child's performance lies in relation to the standardization sample. This can be done at the level of individual items, sub-scores (manual dexterity, ball skills and balance) or for the total score. As described in the manual, raw scores falling below the 5th percentile should be considered as indicative of a definite motor problem, while scores between the 5th and 15th percentile suggest a degree of difficulty that is borderline.

In addition to the quantitative data which the test provides, there is also a qualitative element. For every item in the test, the assessor is encouraged to record **how** the child performs by using a series of descriptors which draw attention to difficulties the child may have concerning control of his/her body and adapting to the particular requirements of the task. In addition, both the test and teacher checklist provide a guide to behavioural factors that may influence motor performance (e.g. timidity, fear of failure).

There have been three published editions of the test. The production of the 1972 edition of the test involved a total of 1,242 British children and 854 Canadian children. The 1984 revision, also standardized simultaneously in Canada and in the U.K., involved 1,200 children and the 1992 version, standardized in the USA, involved 1,234. One of the changes made to the test between 1984 and 1992 was an improvement to the scoring system so that finer distinctions could be drawn between the performance of children who fall in the lowest quartile. Whereas the scores in the *TOMI* were on a three point scale (0-2) for each of the eight tasks, resulting in the highest possible score being 16, the *Movement ABC* has scores on a six point scale (0-5), giving a higher possible total score of 40[1].

The test is now used world-wide and some users have undertaken projects to collect data to establish local norms. Many of these data sets have been made available to us and have been added to a common database alongside the original standardization data. Examination of these data sets is allowing us to investigate the suitability of the published norms for use in different countries.

[1]In the *TOMI*, scaled scores of 0, 1 and 2 represent performance in the centiles: <85, 85-95 and 95-100 respectively. In the *Movement ABC*, 0, 1, 2, 3, 4 and 5 represent performance in the centiles: <75, 75-85, 85-90, 90-95, 95-98 and 98-100 respectively.

The Teachers' Checklist

The *Movement ABC* **Checklist** has been designed to be used primarily by teachers. It contains 48 items which relate to movement activities commonly undertaken by children in the school environment, such as writing, drawing, cutting with scissors, running, ball catching, etc. The 48 tasks appear in four sections, organized according to whether the child is stationary or moving and whether the environment is stable or changing. The teacher is required to observe how well the child performs these tasks and rate their performance on a four point scale, yielding a maximum total score of 144. Based on the performance of a sample of 298 children in the U.K, performance lying below the 5th and 15th percentile can be identified for children of different ages (Sugden & Sugden, 1991). As noted above, the **Test** and **Checklist** also include an identical section inviting the teacher to note how often the child exhibits any behavioural problems which might be related to motor difficulties. The checklist should be filled in over a period of time to allow for careful observation of the child in the classroom and in the playground.

Guidelines for Intervention

A set of guidelines for intervention are also included in the *Movement ABC*. These are based on an approach to intervention which Henderson and Sugden label the Cognitive-motor approach. Built upon the idea that cognitive and affective factors interact with motor control in a dynamic way, the **Guidelines** deal with all aspects of intervention ranging from organizational factors to detailed discussions of how tasks should be presented.

Although all three components of the *Movement ABC* are now being used by both practitioners and researchers, published studies on the newer elements, the **Checklist** and **Guidelines for Intervention** are only just beginning to emerge. Consequently, the main focus of this bibliography is on the component which has existed in published form for longest, the standardized **Test**. However, since the first edition of the *TOMI* (1972) is so out of date now, we have not included any studies which refer to it in this bibliography.

Rationale and Organization of the Bibliography

We receive many inquiries about how the *Movement ABC* should be used and about its suitability for different populations. We hope that this annotated bibliography of studies, published between 1984 and 1996, will help to answer such questions by directing the attention of users to studies employing the test in ways relevant to their interests.

Our work on this compilation has been rendered more congenial by the accumulation of evidence concerning the breadth of interest in the *Movement ABC*. The authors of the studies summarized here are drawn from many different professional groups. These include paediatricians, therapists, teachers and psychologists. Also diverse are the types of children forming the focus of interest. It was the variety of purposes to which the battery has been put, however, which emphasized the need to impose structure on this diversity. To help readers to find their way around the corpus we have opted for division into the following four sections:

Section 1 is devoted to studies in which the test is used to describe and measure the motor performance of different groups of children, ranging from children with a clearly identified medical condition affecting motor performance, through children classified as "clumsy" on purely functional grounds, to children in whom the primary difficulty lies in some other realm, such as language or attention but whose concomitant motor difficulties are of general concern.

Section 2 focuses on longitudinal studies which employ the *TOMI/Movement ABC* to document aspects of children's motor development over an extended period of time. The basic concern of these investigations varies. For some, it might be motor difficulties first detected when the child begins school. For others, the children followed up are those known to be or suspected to be "at risk" in the neonatal period, which includes children born prematurely and/or of low birth weight. In both cases, the length of follow-up varies, with only a few extending beyond school leaving age.

Section 3 describes studies which have used the *TOMI/Movement ABC* in the evaluation of intervention programmes designed to help children with movement difficulties.

Section 4 is devoted to articles concerned with the psychometric properties of the Test and Checklist.

Inevitably, a number of articles could have been appropriately accommodated in more than one of the above sections. In such instances, the entry for that article appears in full in the section we have considered most appropriate, but the reference is also cited in the other appropriate section(s) with a pointer to the one that contains the complete entry.

Format of the Entries

Within each section entries are listed alphabetically by first author. Each entry consists of a full listing of authors, followed by the title and publication details laid out according to the latest format recommended by the American Psychiatric Association (1991). Other information within an entry is set out under a number of sub-headings, as shown below. The amount and type of information available for each study varies considerably. As much of the following information as possible is included:

Summary A brief summary of the study is provided from the author's perspective.

The Edition employed and profession of testers The edition used is noted (*TOMI or Movement ABC*) and if only part of the test was administered then a list of those items used. Where the information is available we have also noted the profession of the person who administered the test.

Reason for using the test Here we have noted why the test was employed e.g. to select subjects, to evaluate change following intervention etc.

Sample characteristics and control procedures Specified under this sub-heading are the procedures employed in selecting subjects, including exclusion criteria. Also recorded are the number, age and gender of the children admitted to the study, the location (town and country) and the setting (school, hospital clinic etc.) in which testing was conducted. Where an impaired group was compared to a control group, the criteria governing admission to a group are specified together with the variables used in matching the groups.

TEST DATA The studies vary enormously in how much detail they provide concerning the *TOMI/Movement ABC* test scores. Whenever the information is available, we report item and sub-scores as well as total scores. When the teacher Checklist was used these results are also presented. Where other measures used in a study have been compared to *TOMI/Movement ABC* scores, the extent and nature of any relationship is reported. Amongst these other measures are formal perceptuo-motor and cognitive tests.

Name and address for correspondence We provide the current address at which the author may be contacted.

Section 1 EXAMINATION OF CHILDREN'S MOVEMENT DIFFICULTIES

The *TOMI/Movement ABC* has been used in many studies which examine the motor performance of children. Broadly speaking, these can be divided into two types, those that simply describe the nature and extent of any movement difficulties and those that take an experimental approach, examining factors considered to underlie the difficulties. The majority of these studies focus on children who might in the past have been called 'clumsy' but who may now be formally classified as suffering from 'Developmental Coordination Disorder' (DCD: American Psychiatric Association, 1994) or 'Specific Developmental Disorder of Motor Function' (SDDMF: World Health Organization, 1992). These are children who have considerable difficulties in the performance of everyday movement tasks in the absence of any obvious sensory, physical or neurological disorder. Very occasionally, the children of interest suffer from a specific and isolated difficulty such as a handwriting problem. The test has also been used with two other groups of children, those who suffer from a clearly identified medical condition affecting motor performance and those in whom the primary difficulty lies in some other realm, such as language or attention but whose concomitant motor difficulties are of general concern.

Most of the studies in this section compare a "target" group of impaired children with a control group. When the target group of children suffers from a clearly identifiable medical condition such as muscular dystrophy, then the selection and classification of subjects does not present a problem. In contrast, the absence of clearly specified criteria for the condition DCD/SDDMF has led to a whole variety of classification criteria being used. Where the *TOMI/Movement* ABC has been employed as the motor measure, there is variation between studies as to the cut-off point used. Some included children only if they scored below the 5th percentile, some used the 10th percentile and some the 15th. Others use terms such as 'mild', 'moderate' and 'definite' motor problems but do not relate these to scores on the test at all (e.g. North et al., 1994).

Many, but not all, of the studies on DCD include some measure of intelligence in the selection procedure (usually a version of the Wechsler Scales). IQ scores are then used to exclude any child whose motor impairment may be said to be attributable to a more pervasive sort of delay. However, the exact cut-off point for exclusion varies between studies, with some using full scale IQ scores and others only the verbal component. For those studies in which both verbal and performance IQ are measured, some report that performance IQ is significantly lower than verbal IQ, although this finding is not consistent. In the best of the studies, IQ is also used as a variable to select matched control children.

The number of boys and girls in the studies focusing on children with DCD is not always specified but when it is, there are always more boys than girls. Due to the nature of the selection procedures, it is not always clear whether this is a true representation of the population from which these children are drawn. However, this pattern does seem to reflect the general finding that more boys suffer from developmental disorders than girls.

Among the studies we have labeled descriptive, some use the *TOMI /Movement ABC* to describe subjects' movement difficulties in detail, reporting individual subject data and commenting on differences in profile, severity etc. For example, in the study by Mercuri et al (1995) of children with muscular dystrophy the test is used to show that only those suffering from a particular type of deficit have fine motor difficulties. Another type of descriptive study uses the test simply to classify children into impaired and 'control' then focuses on the characterization of a particular difficulty the children experience such as fastening buttons, drawing or copying gestures (Bairstow & Laszlo, 1989; Barnett, 1994; Barnett & Henderson, 1992). Such characterization may then extend beyond the motor domain to encompass the educational, social and affective problems such children experience (e.g. Henderson et al., 1989; Schoemaker & Kalverboer, 1994).

In many of the descriptive studies, the *TOMI/Movement ABC* has been used alongside other perceptuo-motor measures. In addition to the studies specifically devoted to documenting the psychometric properties

of the Movement ABC reported in Section 4 of this bibliography, these studies provide data on the validity of the *TOMI/Movement ABC*. Such measures include standardized tests such as the Perceptual-Motor Abilities Test (PMAT; Laszlo & Bairstow, 1985), the Developmental Test of Visual-Motor Integration (Beery, 1982), the Sensory Integration and Praxis Tests (Ayres, 1989) and non-verbal intelligence tests and also non-standardized ones including button fastening and a range of graphic tasks (Barnett & Henderson, 1992, Barnett, 1994).

Other studies have attempted to address specific questions concerning DCD by employing a more experimental approach. Although such studies can yield useful descriptive data, their primary focus has been to compare the performance of a group of children with DCD with a matched control group when specific task variables are manipulated. Using tapping, drawing and pointing tasks, these studies have investigated a range of factors, including visual memory (e.g. Dwyer & McKenzie, 1994), reaction time (Henderson, Rose & Henderson, 1990) and the use of different types of feedback (van der Meulen et al, 1991) in children with DCD. One study has looked specifically at opthalmic factors in children with DCD (Mon-Williams, Pascal & Wann, 1994).

Most of the studies in this section involve children between the ages of 7 and 11 years, although some also include younger children. Thus, some studies have used all age bands of the test, whereas others have used only one or two.

Bairstow, P.J. & Laszlo, J.I. (1989).

Deficits in the planning, control and recall of hand movements, in children with perceptuo-motor dysfunction.

British Journal of Developmental Psychology, 7, 251-273.

Summary
A group of 40 children aged 7 to 11 years with perceptuo-motor dysfunction were examined on two eye-hand coordination tasks: one requiring the interception on a television monitor of a moving target of variable speed and trajectory, the other requiring the tracking and recall of a target moving slowly in a circular path. Performance was compared to developmental norms. Results show that children with perceptuo-motor dysfunction are heterogeneous, and have various ways of carrying out a motor action. Some do not plan a movement, others do not control an ongoing movement like their peers. Yet despite marked abnormalities some children can compensate and be very accurate. Kinaesthetic disability is associated with motor disability. Process-orientated treatment – including kinaesthetic training – improves motor functioning in some domains more than others.
Edition employed: TOMI (1984).
Reason for using the test: To provide an additional index of general motor impairment and to quantify the extent of the children's movement difficulties.
Sample characteristics: 40 children (31 boys, 9 girls) with mean age = 9.3 years (Range: 7-11). All from mainstream schools, selected by teachers because of motor difficulties which were interfering with academic progress. No 'hard' neurological signs were found on examination by a paediatrician. They were impaired on three or more items of the norm-referenced Perceptual-Motor Abilities Test (PMAT; Laszlo and Bairstow, 1985).
TEST DATA: Mean total score = 6.2 (Range: 1-15)
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Barnett, A. (1994).

Graphic Skills of 'Clumsy' Children.

Handwriting Review, 104-112.

Summary
This study examined the nature of the difficulties that 'Clumsy' children experience in a range of tasks involving the control of a writing implement. The performance of 16 Clumsy children was assessed on three graphic tasks:

drawing a figure (Harris, 1963), drawing a triangle and handwriting and compared to that of 16 well-coordinated control children. Composite scores from the three tasks indicated significantly poorer performance in the Clumsy group. Examination of the individual performance profiles revealed that all but one of the children who were 'Clumsy' were poor on the 'motor' aspects of performance, such as the quality of the drawn line. Performance on the 'perceptual' aspects of performance (like the size, shape and proportions) were much more variable. Possible causes and implications of these difficulties are discussed.
Edition employed and profession of tester: TOMI (1984). Administered by a research psychologist.
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Children in London, England aged 5-12 years. Index group (n=16): had been referred to a hospital-based clinic because of motor problems. None had overt physical or neurological impairments but all scored below the 15th percentile on the TOMI. Control group (n=16): selected from a pool of children regarded by teachers as well-coordinated. Children were selected on the basis of a TOMI score above the 15th percentile. They were matched on age, gender and Verbal IQ with the index children. Verbal IQ for both groups was within the normal range with no significant differences between them (WISC-R; Wechsler, 1974).
TEST DATA: Total scores: Index group mean = 10.8 (SD: 3.5, Range: 4.5-16), Control group mean = 1.3 (SD: 1.2). In the index group there was a significant Pearson product-moment correlation between total TOMI scores and a total score for drawing a human figure (using criteria from Goodenough-Harris Draw-a-Man Test, Harris, 1963) ($r=.49$, $p<.05$). Poor performance on the TOMI was also significantly associated with poor motor control in figure drawing ($r=.51$, $p<.05$) and greater errors in tracing a triangle ($r=.52$, $p<.05$).
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Barnett, A. & Henderson, S.E. (1992).

Some observations on the figure drawings of clumsy children.

British Journal of Educational Psychology, 62, 341-355.

Summary
This paper presents two exploratory studies of figure drawing by clumsy children. In the first, the drawings of 42 such children and controls, matched pair-wise on chronological age and Verbal IQ, were compared. Not only were the impaired children's drawings found to be generally delayed but there was also a suggestion that some fell further behind their peers as they got older. In a follow-up study of a subset of the clumsy group it was found that increasing delay was indeed characteristic of some children, but others improved. In spite of improvement in some aspects of figure representation, however, the children's poor motor control persisted.
Edition employed and profession of tester: TOMI (1984). Administered by a research psychologist.
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Children aged 5-13 years. Index group (n=42): mean age = 106.6 months (SD; 24.3, Range: 63-155). Each child had been referred to either an occupational therapist or a physical education teacher with a special interest in children with movement difficulties. All had Verbal IQ >80. None had a known physical, neurological or visual deficit. Thirty four attended mainstream school. Control group (n=42): well-coordinated children selected to match index children on age, gender, Verbal IQ and type of school. The Verbal IQs of both groups were within the normal range (all > 80) with no significant differences between them (WISC-R; Wechsler, 1974). There was, however, a greater range in Performance IQ, which was significantly lower in the index group (mean 81.76 vs 105.43, $p<.001$).

TEST DATA: Total scores: Index group mean = 9.16 (SD: 3.21, Range: 4.5-16), Control group mean = 1.12 (SD: 1.05, Range: 0-3.5). The difference between the groups was statistically significant (p<.001). TOMI scores correlated significantly with scores for drawing a figure (Goodenough-Harris Draw-a-man Test, Harris, 1963) (r=.78) and with Performance IQ (r=.68).

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Barnett, A. & Henderson, S.E. (1994).

Button fastening as a prototype for manipulative action: Some observations on clumsiness.

In J.H.A. van Rossum & J.I. Laszlo. *Motor Development: Aspects of normal and delayed development.* Amsterdam: VU University Press. Ch. 9. Pp. 99-115.

Summary
The manipulative skill of a group of 42 Clumsy children, aged 5-12 years was assessed using a button fastening task. Speed and quality of performance was compared to that of well coordinated control children matched pairwise on age, gender and Verbal IQ. Children in the Clumsy group performed the task significantly more slowly than the control children. They also exhibited significantly more 'errors' of performance as recorded on a concurrent observational checklist. These included errors of motor control (poor posture and grip) as well as errors in the way that they responded to the particular demands of the task (being unable to locate the button and hole). Differences between the groups on both speed and quality of performance appeared to diminish with age. A sub-set of sixteen of the Clumsy children were followed-up using the same task after an 18 month period. Although there were some individual differences, at the group level improvements were found in both the speed and quality of performance. However, in neither aspect had they 'caught up' with their well coordinated peers. An examination of the individual errors of performance revealed that some aspects of performance had improved whilst others were more resistant to change.

Edition employed and profession of tester: TOMI (1984). Administered by a research psychologist.

Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.

Sample characteristics and control procedures: Children aged 5-12 years with Verbal IQ > 80. Index group (n=42): Children had been referred to either an Occupational Therapist or a Physical Education teacher with a special interest in children with movement difficulties. Criteria for inclusion was a score below the 15th percentile on the TOMI (>4.5). Mean age = 106.6 months (SD: 24.3, Range: 63-155). Control group (n=42): From a pool of children regarded by teachers as well-coordinated, children were selected on the basis of a TOMI score above the 15th percentile(<4.5) and matched with the index children on age, gender and Verbal IQ. Mean age = 107.0 months (SD: 29.0, Range: 63-160). Verbal IQ was in the normal range with no significant differences between the groups (WISC-R; Wechsler, 1974). There was a greater range in Performance IQ, which was significantly lower in the index group (mean 81.76 vs 105.43, p<.001).

TEST DATA: Total scores: Index group mean = 9.16 (SD: 3.21, Range: 4.5-16), Control group mean = 1.12 (SD: 1.05, Range: 0-3.5). The difference between the groups was statistically significant (p<.001). TOMI scores correlated significantly with completion time and the number of recorded errors in a button fastening task (r =.69 and r =.64 respectively).

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Bouffard, M.E., Watkinson, J., Causgrove Dunn, J.L. & Romanow, S.K.E. (1996).

A test of the activity deficit hypothesis with children with movement difficulties.

Adapted Physical Activity Quarterly, 13, 61-73.

Summary
The aim of this study was to test the hypothesis that children with movement difficulties are less physically active during playtime than age-and gender-matched controls without movement difficulties due to a deficit in overall activity levels. An observational study was conducted over a 2-month period in playground settings with 52 subjects. Findings revealed that during playtime, children with movement difficulties were vigorously active less often, played less often with large playground equipment and spent less time in positive social interactions with others of their own gender. Accordingly, it was concluded that the data supported the activity deficit hypothesis.
Edition employed and profession of tester: TOMI (1984). Administered by the authors and three trained graduate students in physical education.
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics: 52 children from 14 schools in a large Canadian urban community, divided into two age groups: the younger boys mean age = 80.1 months (SD: 9.4) and girls mean age = 84.3 months (SD: 9.5). The older boys mean age = 107.9 (SD: 5.9) and girls mean age = 103.1 (SD: 6.1). Index group (n=26): identified by teachers who considered them to have movement difficulties, obtained at least 4 on the test. Control group (n=26): randomly selected to match the index children for class, gender and age (±6 months), obtained less than 4 on the test.
TEST DATA: Total scores: Index younger mean = 6.69 (SD: 2.11), Index older mean = 7.64 (SD: 2.72). Control younger mean = 0.35 (SD: 0.69), Control older mean = 1.42 (SD: 1.24).
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Cermak, S.A., Ward, E.A. & Ward, L.M. (1986).

The relationship between articulation disorders and motor coordination in children.

American Journal of Occupational Therapy, 40(8), 546-550.

Summary
This study was designed to examine the relationship between articulation disorder, soft neurological signs and motor abilities. Fifteen children with articulation problems, as measured by the Templin-Darley Articulation Screening Test and a connected speech sample, were compared with a normal control group (matched for sex and age) on the Quick Neurological Screening Test, the Imitation of Postures Test (from the Southern California Sensory Integration Tests) and the TOMI. A significant difference was found between the groups on the TOMI and the Quick Neurological Screening Test, supporting the hypothesis that the children with articulation disorder would have more motor coordination problems and soft neurological signs than the normal children in the control group. There was no between-group difference on the Imitation of Postures Test, suggesting that as a group, children with articulation deficits are not 'dyspraxic'. This study supports other research findings positing a relationship between articulation problems and motor impairment, but it also indicates that this motor impairment is not necessarily dyspraxia.
Edition employed: TOMI (1984).
Reason for using the test: To assess and compare motor competence in children with articulation disorders and control children.
Sample characteristics and control procedures: Children aged 5-8 years from a middle- to upper middle-income suburban public school in Massachusetts, U.S.A. All were free from obvious physical limitations such as deformities, paralysis and weakness. None were diagnosed as being learning disabled. Index group (n=15,

9 boys, 6 girls), identified by the speech and language pathologist in their school as having articulation problems, scored below 1 SD on the Templin-Darley Articulation Screening Test (Templin & Darley, 1964) and/or made 10% or more articulation errors in a speech sample of 50 connected words. Mean age = 82.7 months (SD: 11.7). Control group (n=15): matched with the index group by gender and age (within 6 months).
TEST DATA: Total scores: Index group mean = 4.23 (SD: 3.40), Control group mean = 1.83 (SD: 1.32). The difference between the groups was statistically significant [$F(1,28) = 6.48$, $p<.05$)]. Six subjects in the index group and one in the control group scored in the 'impaired' category of the test (4+ points), (Fisher Exact Probability Test calculated with $p = .04$). A correlation between the TOMI scores and the Imitation of Postures Test (Ayres, 1980) standard score was not statistically significant ($r = .14$)
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Dussart, G. (1994).

Identifying the Clumsy child in school: an exploratory study.

British Journal of Special Education, 21(2), 81-86.

Summary
This paper describes the development of a new checklist for teachers to identify children who might have Developmental Coordination Disorder in the normal school population. Based on a wide range of behavioural symptoms, the final version of the checklist has two sections, one (A), containing 12 items most closely associated with DCD and another (B) containing 31 less frequently noted items. Concurrent validity of the checklist was examined using the TOMI and a significant relationship was found. The checklist was used to assess whether incidence rates in East Kent are similar to those quoted in the literature and to test the hypotheses that there would be a relationship between (1) DCD and left-handedness and (2) DCD and self-concept.
Edition employed: TOMI (1984).
Reason for using the test: To assess the concurrent validity of a new checklist and to examine the relationship between (1) DCD and handedness and (2) DCD and self-concept.
Sample characteristics: Children from East Kent schools, U.K, each with different social backgrounds.
TEST DATA: Regression analyses of the TOMI scores and the total checklist score showed a significant relationship ($p<.01$). This relationship was stronger for items in section A than for those in B ($p<.001$). 48% of children identified by the checklist had TOMI scores below the 5th and 75% had scores below the 15th percentile. Multiple regression analyses on groups of items on the checklist showed that only movement and behaviour significantly correlated with TOMI scores ($p<.01$ and $p<.05$ respectively). Incidence of left-handedness was 8.1% in children scoring less than 3 on the TOMI, 25% in those scoring between 3-16 and 8% in those scoring 6-16. There was no significant relationship between TOMI scores and a measure of self-concept (using a modified oral version of the Piers-Harris self-concept scale, Piers & Harris, 1964).
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Dwyer, C. & McKenzie, B.E. (1994).

Impairment of visual memory in children who are 'clumsy'.

Adapted Physical Activity Quarterly, 11(2), 179-189.

Summary
In order to evaluate the contribution of visual memory to problems in the development of motor coordination, 9-13-year-old boys who were 'clumsy' were tested on a graphic reproduction task under two delay conditions.

Their performances were compared with those of well co-ordinated control children. Individual geometric patterns were presented as a whole or sequentially and children reproduced these patterns immediately after the inspection period or after a delay of 15 seconds. There was no difference in the accuracy of the reproductions of the two groups on immediate recall. After the 15-second delay, the reproductions of children who were clumsy were markedly less accurate, whereas those of the control children were unchanged. Although children who were 'clumsy' completed their reproductions more quickly, there was no correlation between their accuracy scores and response duration. It was concluded that a difference in visual rehearsal strategies may distinguish children who are 'clumsy' from their peers.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Australian boys aged 9 -13 years old. Index group (n=19): initially selected by teachers as experiencing gross and fine coordination problems. Score of 4.5 or more was used as the criterion for inclusion in the index group. Control group (n=19): matched on gender, chronological age, scholastic level and non-verbal intelligence (using Standard Progressive Matrices, SPM).
TEST DATA: Total scores: Index group mean = 6.7 (SD: 2.1; Range: 4.5-12.5), control group mean = 1.7 (SD: 1.2; Range: 0-3.5). Significant negative correlations were found between TOMI scores and drawing scores in the index group but not in the control group. A significant negative correlation was also found between TOMI scores and SPM scores in the index group (.52, $p<.05$) but not in the control group (.42)
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Geuze, R.H. & Kalverboer, A.F. (1994).

Tapping a rhythm: A problem of timing for children who are clumsy and dyslexic?

Adapted Physical Activity Quarterly, 11(2), 203-213.

Summary
This study is concerned with deficits in the ability to maintain an imposed rhythm in a tapping task and the possible sources of these deficits. Three groups of children between the ages of 7 and 12 with IQs above 75 participated: a group of children who were clumsy, a group who were dyslexic and a control group whose reading and coordination were considered age appropriate. The children performed a series of "continuation" tapping tasks in which hand, speed and rhythm of tapping were manipulated. The performance measure taken was the variability of tapping after the pacing signal had ceased. When the three groups were compared, the children who were clumsy showed a slightly increased variability across all tasks but no sign of lateralized performance differences. In contrast, the children who were dyslexic showed increased variability in only one task, involving the right hand. The results are discussed in relation to three different models of dysfunction.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To assign children to groups with or without movement difficulties.
Sample characteristics and control procedures: Children aged 7-10 years attending a school for children with specific learning difficulties in the north of Holland. Teachers identified three groups of children: those with reading problems, those with motor problems and those without reading or motor problems. Only those with Full scale IQ ≥ 75 (using the WISC-R) were included. 'Clumsy' group (n=11, 9 boys, 2 girls): All obtained a TOMI score > 4.5 (below the 15th percentile) and were no more than one year behind in reading ability. Mean age = 113 months. 'Dyslexic' group (n=12, 6 boys, 6 girls): All obtained a TOMI score < 4 (in the normal range) with reading ability more than 1.5 years below the expected level. Mean age = 135 months. Control group (n=12, 8 boys, 4 girls): All obtained a TOMI score < 4 and were less than one year behind in reading ability. Mean age = 126 months.

TEST DATA: Total scores: 'Clumsy' group mean = 7.4, 'Dyslexic' group mean = 1.7, Control group mean = 2.0.
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Geuze, R.H. & van Dellen, T. (1990).

Auditory precue processing during a movement sequence in 'clumsy' children.

Journal of Human Movement Studies, 19, 11-24.

Summary
Perceptual anticipation was studied in a group of twelve 7 to 12 year old 'clumsy' children and their matched controls by precuing during a movement sequence. Precues were placed at several positions during the first fast goal directed movement element to detect possible interference between the precue and the ongoing movement. Perceptual anticipation was measured as a decrease in reaction time (RT) of the movement to the next target. No difference between groups was found in the ability to profit from precued information. 'Clumsy' children were slower both in RT and movement time. Individual assessment of anticipation revealed that in the present groups the 7 year olds did not anticipate. All of the older control children (N=6) clearly anticipated whereas only 3 of 6 of the older 'clumsy' children anticipated. It is suggested that those children that do not profit from precued information have a limitation in their information processing capacity.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To select children for the 'clumsy' and control groups.
Sample characteristics and control procedures: Children aged 7-13 years. Index group (n=12, 10 boys, 2 girls): mean age = 9.1 years. Children were selected from normal primary schools by, firstly, a teacher questionnaire of fine and gross motor function and secondly the TOMI (scoring below the 10th percentile). Control Group (n=12) matched for age and gender with the index group. Mean age = 9.2 years. All scored well on the teacher questionnaire and on the TOMI (above the 25th percentile).
TEST DATA: none provided
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Henderson, L., Rose, P. & Henderson, S.E. (1992).

Reaction time and movement time in children with a developmental coordination disorder.

Journal of Child Psychology and Psychiatry, 33, 895-905.

Summary
Twelve children with Developmental Coordination Disorder (DCD) were matched pair-wise on chronological and reading age with twelve unimpaired children. Teachers' rating provided an initial cue to motor status but the formal criterion for group membership was a score of 5 or more (DCD) vs. one or less (Control) on the Test of Motor Impairment (TOMI). The two groups were compared on an aiming task, with two target sizes, and a coincidence timing task. In the aiming task, simple reaction times and movement times were both significantly prolonged in the DCD group, and the trial to trial variability of movement times was greater in DCD individuals. In coincidence timing, constant error did not distinguish between the groups, the overall tendency being to respond late. However, absolute error was significantly greater in the DCD group. The most robust chronometric

effect for differentiating the two groups seemed to be movement time, with the smaller target. A multiple regression analysis, using TOMI, chronological age and reading age as predictors of movement time showed that TOMI was a powerful indicator of movement time.

Edition employed: TOMI (1984).

Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.

Sample characteristics and control procedures: Children aged 7.8-11.6 years. Index group (n=12, 10 boys, 2 girls): Identified by teachers as having coordination difficulties that were primary i.e. not an immediate consequence of physical, neurological or intellectual impairment. All had total TOMI scores > 6 (corresponding to the 5th percentile). Mean age = 9.3 years. Control group (n=12): All had TOMI scores not exceeding one. Matched pairwise to index children on gender, chronological age, reading age and educational experience, and drawn from the same class.

TEST DATA: Index group total scores Range = 6-11. Control group total scores Range = 0-1. Product-moment correlations between total TOMI scores and movement time in a simple aiming task were statistically significant ($r = 0.76$ for all subjects, $r = 0.59$, $p<.05$ for the index group only).

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Henderson, S.E., Barnett, A. & Henderson, L. (1994).

Visuospatial difficulties and clumsiness: On the interpretation of conjoined deficits.

Journal of Child Psychology and Psychiatry, 35(5), 961-969.

Summary
Sixteen children with motor difficulties and 16 controls, matched on age, gender and verbal IQ, were assessed on the Test of Motor Impairment, various graphic tasks and a measure of visuospatial discrimination. Poor perceptual and motor performance tended to co-occur but contrary to the visuospatial deficit account of clumsiness these abilities were uncorrelated even when attention was restricted to the less proficient children. There was no tendency for the control group's superiority in graphic reproduction to diminish when visual feedback was withheld. Some suggestions are offered concerning more appropriate methods for framing and testing causal deficit hypotheses.

Edition employed and profession of tester: TOMI (1984). Administered by a research psychologist.

Reason for using the test: To obtain an objective measure of motor impairment/ competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.

Sample characteristics and control procedures: Children aged 7-12 years with verbal IQ > 80 (using WISC-R). Index group (n=16): all had been referred to an outpatient clinic because of motor problems and met a normative criterion of incoordination, scoring below the 15th percentile on the TOMI. Mean age = 7 years 7 months (SD: 1.7). Controls (n=16): from a pool of children regarded by teachers as well coordinated, controls were selected on the basis of a TOMI score above the 15th percentile (<4.5) and matched on age, gender and verbal IQ with a member of the index group.

TEST DATA: Total scores: Index group mean = 10.8 (SD: 3.5), Control group mean = 1.3 (SD: 1.2). Difference between the groups was statistically significant for the total score ($p<.001$) and each of the eight test items (t min. = 2.96, $df(30)$, p,.005). Significant correlations were found between TOMI scores and figure drawing scores (Goodenough-Harris Draw-a-man test, Harris, 1964) ($r = .84$) and TOMI scores and tracing (Lord & Hulme, 1988) ($r = .84$) for the entire data set.

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Henderson, S.E., May, D.S. & Umney, M. (1989).

An exploratory study of goal-setting behaviour, self-concept and locus of control in children with movement difficulties.

European Journal of Special Needs Education, 4(1), 1-15.

Summary
Eighteen children referred to clinics because they lacked adequate motor competence and 18 well-coordinated children were compared on measures of goal-setting, self-concept and locus of control. The results showed that the children with movement difficulties were unrealistic in the way they set goals for themselves, had lower self-esteem and were less inclined to accept responsibility for what might happen to them. The three different measures of self-regard did not, however, correlate with one another.
Edition employed: TOMI (1984). When a child did not pass at his/her own age level, they were tested at subsequently lower age levels until a pass was obtained.
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Children aged 7 years 8 months to 11 years 9 months attending normal junior schools. All had full-scale WISC IQ scores above 70. Index group (n=18, 15 boys, 3 girls): All attended Child Development Centres attached to London teaching hospitals to receive remedial help for their co-ordination problems. Control group (n=18): selected from an inner city junior school. Individually matched with children from the index group on gender, age and IQ.
TEST DATA: Total scores: Index group mean = 17.0 (SD: 5.0, Range: 10-28), Control group mean = 0.5 (SD: 1.0, Range: 0-2). There was no overlap between the groups.
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Maeland, A.F. (1992)

Handwriting and perceptuo-motor skills in clumsy, dysgraphic and 'normal' children.

Perceptual and Motor Skills, 75, 1207-1217.

Summary
Among various perceptual-motor tests, only visuomotor integration was significant in predicting accuracy of handwriting performance for a total sample of 59 children consisting of 19 clumsy, 22 non-clumsy dysgraphic and 18 'normal' children. They were selected from a sample of 360 fourth-graders (10-year olds). For groups of clumsy and 'normal' children, the prediction of handwriting performance is difficult. However, correlations among scores on 6 measures showed that handwriting was significantly related to visuomotor integration, visual form perception, and tracing in the total group and to visuomotor integration and visual form perception in the clumsy group. The weakest correlations occurred between tests measuring simple psychomotor functions and handwriting. Moreover, clumsy children were expected to do poorly on tests measuring aiming, tracing and visuomotor integration, but not on tests measuring visual form perception and finger tapping. Dysgraphic children were expected to do poorly on visuomotor integration only.
Edition employed: TOMI (1984).
Reason for using the test: To identify children with coordination problems.
Sample characteristics and control procedures: 360 (183 boys, 177 girls) 10 year olds from seventeen mainstream school classes from eight public schools in Trondheim, Norway. Schools were chosen randomly and covered a representative socioeconomic range.
TEST DATA: 5.3% (15 boys, 4 girls) obtained scores of six or more, indicating definite motor problems. 57.9% of these children also had handwriting problems (10 boys, 1 girl).

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Maeland, A.F. (1992)

Identification of children with motor coordination problems.

Adapted Physical Activity Quarterly, 9, 330-342.

Summary
This study focuses on the identification of children with motor coordination problems and investigates whether the incidence of children with such problems in a normal school setting in Norway is comparable to that found in other countries using the same tests and criteria. The study also examines the level of agreement between two motor tests, the Test of Motor Proficiency (TMP; Gubbay, 1975) and the Test of Motor Impairment (TOMI), and teachers' judgment in identifying clumsiness among 360 10-year old children. The results showed that while the three different assessment methods identified about the same number of children with such problems (5-5.6%), each measure identified a somewhat different set of children. The lack of agreement demonstrates the difficulty in assessing subtle motor coordination problems or clumsiness.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To identify children with coordination problems.
Sample characteristics and control procedures: 360 children (177 girls, 183 boys) from eight randomly selected schools in Trondheim, Norway participated in the study. The TOMI was administered to all of the children from five classes (n=99, 44 girls, 55 boys) plus all those identified by the Test of Motor Proficiency (TMP; Gubbay, 1975) as clumsy, or so judged by the teachers (n=124), giving a total sample of 223. Three children were excluded, one who was found to have glaucoma and two who had been involved in car accidents, leaving 220.
TEST DATA: Of the 99 children from the five classes, 4 boys and 1 girl obtained a score of 6 or more. Of the total sample tested (n=220), 14 children (4 girls, 10 boys) or 3.9% obtained a score of 6 or more. If borderline cases are included, then 19 children (4 girls, 15 boys) or 5.3% are identified. There was a significant difference in the incidence rate for girls (2.3%) and for boys (8.2%), p<.05.10/19 (52.6%) children defined by the TOMI as having motor problems were also identified as such by the teachers (with the proportion of agreement calculated as 0.45). The same proportion were also identified by the TMP (with the proportion of agreement calculated as 0.51). Better agreement was obtained for the TOMI and the two other measures than between any of the others.
Correspondence to:
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Maeland, A.F. (1994).

Self-esteem in children with motor coordination problems (clumsy children).

Handwriting Review, 128-133.

Summary
The purpose of the present study was twofold. Firstly, it was to examine whether there are differences between well coordinated children and those with motor coordination problems with respect to their perceived competence using the Perceived Competence Scale for Children (Harter, 1979). Secondly, it was to examine levels of self competence in the cognitive and physical domains against actual levels of competence. Two groups of 19 children participated in the study, one group with and one without coordination problems. On the Harter scale, the group with coordination problems had lower cognitive, social, physical and general scores but the

difference between the groups was only significant for the physical domain. However, when the childrens' scores on the TOMI were taken into account it was found that this difference was no larger than could be explained by the difference in actual performance levels. The Clumsy children also performed more poorly than the well coordinated children on assessments of reading, spelling and arithmetic. However when this performance was compared to their scores on the cognitive domain of the Harter scale, it was found that the Clumsy children overestimated their competence, a finding which was significant for both reading and arithmetic.

Edition employed: TOMI (1984).

Reason for using the test: To obtain an objective measure of motor impairment/competence. To identify children with coordination problems.

Sample characteristics and control procedures: Index group (19 children, 15 boys, 4 girls): identified as having motor problems from a screening sample of 360 10-year olds (183 boys, 177 girls). Screening sample selected by random from 17 classes in eight public schools in Trondheim, Norway. Control group: matched with index children for gender, with surnames next alphabetically in the same classroom. All had normal motor development.

TEST DATA. Not reported. TOMI scores were used as a covariate in a one-way Analysis of Variance looking at differences between the groups on the physical dimension from the Harter Perceived Competence Scale for Children (1979). No significant difference between the groups was found.

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Maeland, A.F. & Sovik, N. (1993).

Children with motor coordination problems and learning disabilities in reading, spelling, writing and arithmetic.

European Journal of Special Needs Education, 8 (2), 81-98.

Summary
The present study was conducted to investigate the incidence of motor coordination problems (clumsiness) among 10-year-old learning disabled children and to examine the characteristics of children with motor coordination problems. It was found that the strongest relationship between motor and learning problems seemed to exist in handwriting and arithmetic and the weakest in reading. With regard to the assignment to different subgroups based on deficient reading and spelling strategies, more clumsy children with dyslexic problems were classified in the 'phonological' and 'mixed' groups than in the 'morphemic' group. This study also supports the heterogeneity of children labelled 'clumsy. The clumsy children varied widely in their characteristics and concomitant disabilities. No significant difference between the children with motor problems and a control group of 'normal' children was found when intelligence was accounted for.

Edition employed: TOMI (1984).

Reason for using the test: To obtain an objective measure of motor impairment/competence. To identify children with coordination problems.

Sample characteristics and control procedures: 360 (183 boys, 177 girls) 10 year olds from seventeen mainstream school classes from eight public schools in Trondheim, Norway. Schools were chosen randomly and covered a representative socioeconomic range. Those identified with motor problems were matched for gender with control children being next on the register all with normal motor development.

TEST DATA: 5.3% (15 boys, 4 girls) obtained total scores of six or more, indicating definite motor problems. Most children in this group had lower performance than verbal scores on the WISC.

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Manjiviona, J. & Prior M. (1995).

Comparison of Asperger syndrome and high-functioning autistic children on a test of motor impairment.

Journal of Autism and Developmental Disorders, 25(1), 23-39.

Summary
This study compared the levels of motor impairment of children with Asperger syndrome and those with high functioning autism using a standardized test, the Test of Motor Impairment. The two groups did not differ on either total or sub-scale impairment scores. Intelligence level was negatively correlated with motor impairment although the relationship was mostly accounted for by the Asperger children. There was considerable variability within both clinical groups but 50% of Asperger children and 67% of autistic children showed a clinically significant level of motor impairment. Results offer no support for clumsiness as a diagnostically differentiating feature of these disorders .

Edition employed: TOMI (1984)

Reason for using the test: To assess and compare motor competence in children with Asperger Syndrome and high functioning autism.

Sample characteristics and control procedures: A total of 21 children participated (16 boys, 5 girls) mean age = 11.5 years (SD: 2.4; Range: 7-17). 20 children were in normal school and one was in a special school. IQs were in the normal or near normal range (measured by WISC-R, 1984 or WAIS-R, 1981). All but one child was tested at La Trobe University. Children: were assessed individually and diagnosed according to DSM III-R or ICD-10. Asperger Syndrome Group (AS) (n=12): Mean age = 10.9 years (SD: 2.7; Range 7-17). Full IQ mean = 104.2 (SD: 22.2, Range: 71-136), Verbal IQ mean = 101.5 (SD: 18.6; Range: 72-130), Performance IQ mean = 104.4 (SD: 23.2; Range: 72-434). High functioning autism Group (HFA) (n=9): Mean age = 12.3 years (SD: 1.8; Range 10-15). Full IQ mean = 84.9 (SD: 17.5; Range: 67-121), Verbal IQ mean = 85.8 (SD: 25.8; Range: 54-142), Performance IQ mean = 85.1 (SD: 9.3; Range: 70-96). There was no significant difference between the groups in age, Full scale or Verbal IQ. The AS group had significantly higher Performance IQ (F=5.50, p= .03).

TEST DATA: All individual results are provided. AS mean = 7.0 (SD: 5.6; Range 0-16), HFA mean = 7.9 (SD: 3.9; Range 2-14). There was no significant difference between the two groups on total TOMI scores or on any of the three sub-scales. 50% (6/12) AS had total scores of 6 or more, 66.7% (6/9) HFA had total scores of 6 or more. There was no significant difference in the test profiles for the two groups. Pearson correlations between total TOMI scores and Full scale IQ was r=-.53, p=.013 and for total TOMI scores and Performance IQ r=-.61, p=.003 for both groups together. Only 28% of the variance in TOMI scores was accounted for by Full scale IQ. The relationship between IQ and TOMI scores was mostly accounted for by the AS group. With the AS group, Pearson correlations between TOMI and Full Scale IQ was r=-.66, p=.02, TOMI and Verbal IQ r=-.62, p=.03 and TOMI and Performance IQ r=-.69, p=.01. The authors warn that these should be interpreted with caution because of the individual differences. There were no significant correlations between IQ and TOMI scores for the HFA group. When Full scale IQ was used as a co-variate, the AS and HFA groups were not differentiated on the basis of their TOMI performance. A very detailed account is provided of qualitative behaviour of the children in the study.

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Mercuri, E., Dubowitz, L., Berardinelli, A., Pennock, J., Jongmans, M., Henderson, S. Muntoni, F., Sewry, C., Philpot, J. & Dubowitz, V. (1995).

Minor neurological and perceptuo-motor deficits in children with congenital muscular dystrophy: Correlation with brain MRI changes.

Neuropediatrics, 26, 156-162.

Summary
The aim of this study was to asses fine motor and perceptuo-motor abilities in children with a "pure" form of congenital muscular dystrophy (CMD), in which there are no structural changes in the brain or severe mental retardation. Comparisons were made between those children with and without diffuse white matter changes on magnetic resonance imaging (MRI). Twenty-two children with "pure" CMD were investigated with a standard neurological examination and a battery of tests (the Manual Dexterity items from the Movement ABC, the test of visual-motor integration and the Zurich Neuromotor test). A significant difference was found for all the tests between the group of CMD children with normal MRI and the group with diffuse white matter changes. The manual dexterity and the Zurich Neuromotor tests showed a greater sensitivity than the test of visual-motor integration, which had some false negatives. In the group with diffuse white matter changes, the presence of contractures or weakness did not seem to affect the quality of performance, all these children scored abnormally on the test, irrespective of the severity or extent of contractures and weakness. In contrast, in children with normal MRI severe contractures and weakness did affect the performances. The results demonstrate that perceptuo-motor difficulties and minor neurological soft signs are a consistent feature in CMD children with diffuse MRI changes but not with normal MRI. A more detailed neurological examination for the detection of these abnormalities may lead to more specific supportive help for everyday life and school performances in these children. The concordance of the results with MRI findings also suggest that these tests might provide an additional help in identifying subgroups of CMD.
Edition Employed: Movement ABC (1992), three Manual Dexterity items only.
Reason for using the test: To assess fine motor abilities in children with congenital muscular dystrophy and compare those with and without white matter changes on MRI.
Sample Characteristics: 22 children with "pure" CMD (12 girls, 10 boys). All attended the Neuromuscular Clinic at the Hammersmith Hospital in London, U.K. Mean age = 8 years, 9 months (Range: 4 years, 5 months-16 years). All fulfilled the criteria of the International Consortium on CMD for genetic linkage studies with onset of the disease before 6 months of age with hypotonia, weakness and delayed motor development. In all cases the diagnosis was confirmed by needle muscle biopsy. Patients with ocular abnormalities, structural brain changes or severe mental retardation were excluded. Normal MRI group (n=12): children with normal MRI scans. MRI changes group (n=10): 9 had diffuse white matter (WM) changes and one child had localised WM changes.
TEST DATA: All manual dexterity scores below the 15th centile were considered abnormal and graded as mild when falling below the 15th and severe when below the 5th. Twelve of the 21 children tested had normal manual dexterity, 9 were abnormal (2 mild and 7 severe). Normal MRI group: 11 had normal scores (Range: 0-5), one showed severe abnormalities with a score of 15. MRI changes group: 8 had abnormal scores (Range: 5-15, two were graded as mild and six as severe). The child with localised WM changes had a normal score (of 3). One of the children with diffuse WM changes was unable to perform the items because of severe weakness. A significant difference ($p<0.01$) was found between the group with normal MRI and the group with diffuse WM changes (Fisher Exact Test). The sensitivity of the test in children with diffuse WM changes was 0.9, specificity was 1, positive predictive value 1 and negative predictive value 0.91.
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Mon-Williams, M.A., Pascal, E. & Wann, J.P. (1994).

Ophthalmic factors in developmental coordination disorder.

Adapted Physical Activity Quarterly, 11(2), 170-178.

Summary
The aim of this study was to examine ophthalmic function in children with Developmental Coordination Disorder (DCD). Ocular performance of 29 children with DCD and 29 randomly selected controls was assessed with a battery of five ophthalmic tests. No significant differences were found in visual status between the two

groups. Strabismus was found in 5 children from both groups. All 5 children with strabismus from the DCD group showed a similar movement profile on the Movement ABC Checklist. While a causal relationship cannot be discounted, the presence of strabismus appears more likely to be a "hard" neurological sign of central damage common to this group. The evidence seems to indicate that a simple ophthalmic difficulty does not explain problems with movement control.
Edition employed: Movement ABC (1992)Test and Checklist. Checklist administered by child's teacher.
Reason for using the test: To obtain an objective measure of motor impairment/competence. To select children with DCD and to confirm that control children were well coordinated.
Sample characteristics and control procedures. The groups were selected from 500 children aged 5-7 years from five schools situated in extremely socially deprived areas in a large Scottish city. Index group (n=29): identified by teachers as lacking motor competence and scored below the 5th percentile on the test. Control group (n=29): For each index child, a control child of the same age and gender was randomly selected from the class list. All obtained a score of <3.5 on the Movement ABC.
TEST DATA: No data provided.
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Murray, E.A., Cermak, S.A. & O'Brien, V. (1990).

The relationship between form and space perception, constructional abilities and clumsiness in children.

American Journal of Occupational Therapy, 44(7), 623-628.

Summary
The Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989) were administered to 21 children with learning disabilities and 18 children without learning disabilities, aged 5 to 8 years. The children with learning disabilities were divided into two groups, clumsy and non-clumsy, on the basis of their scores on the Test of Motor Impairment. It was hypothesized that the learning-disabled children in the clumsy group would score significantly lower than the learning-disabled children in the non-clumsy group on the six SIPT sub-tests that measure form and space perception and visual construction and that the non-clumsy learning-disabled children, in turn, would score significantly lower than the non-learning-disabled children. It was further hypothesized that there would be a significant correlation between the degree of clumsiness and the degree of visual-perceptual and constructional deficits. An analysis of the data indicated that both groups of learning-disabled children scored lower than the non-learning-disabled children on four of the six SIPT sub-tests. The clumsy and non-clumsy children with learning disabilities, however, differed from each other on only two sub-tests. The degree of clumsiness correlated significantly with three of the six sub-tests. The results are discussed in terms of variations in perceptual and motor skills related to subtypes of learning disabilities
Edition employed and profession of tester: TOMI (1984). Administered by an Occupational Therapist.
Reason for using the test: To sub-divide a group of children with learning difficulties into a 'clumsy' and 'non clumsy' group. To confirm that the control children were well coordinated.
Sample characteristics and control procedures: 39 children aged 5-8 years attending public and private schools within the greater Boston, Massachusetts area. Index groups (n=21): each child had a diagnosed learning disability and was receiving special education for his/her specific disability. Age range = 5,4-8,7. Subdivided into two groups on the basis of TOMI scores: 'Clumsy' group (n=12) with scores of 4+ and mean age = 80.7 (SD: 11.2), 'non-clumsy' group (n=9) with scores of 3.5 or less and mean age = 82.4 months (SD: 13.7). Control group (n=18): did not have learning disabilities. All in age-appropriate grade at school and had no special education requirements and no history of receiving remedial help. Mean age = 82.8 months (Range: 5,1 -8,10). There was no difference in age among the three groups ($F(2, 36) < 1$, $p=.91$).
TEST DATA: 'Clumsy' group mean total score = 8.04 (SD: 2.31), 'non-clumsy' group mean total score = 2.28 (SD: 1.12), control group mean total score = 1.94 (SD: 1.52). Significant correlations were found between total TOMI scores and

three of the six sub-tests of the Sensory Integration and Praxis Tests (SIPT; Ayres, 1989): Space visualization (-.47, p<.05), Motor Accuracy (-.53, p<.01) and Design Copying (-.50, p<.05) for the children with learning disabilities.

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O'Brien, A., Cermak, S.A. & Murray, E. (1988).

The relationship between visual-perceptual motor abilities and clumsiness in children with and without learning disabilities.

American Journal of Occupational Therapy, 42(6), 359-363.

Summary
One visual-perceptual test, four visual-motor tests and a test of motor impairment were administered to 22 children with learning disabilities and 22 children without learning disabilities, aged 5 to 8 years. The children with learning disabilities were divided into two groups – "clumsy" and "non clumsy" – based on their scores on the motor impairment test. It was hypothesized that the clumsy children with learning disabilities would score significantly lower on visual-perceptual and visual-motor tests than the non-clumsy children with learning disabilities who, in turn, would score significantly lower than the children without learning disabilities. It was further hypothesized that there would be a significant correlation between the degree of clumsiness and the degree of visual-perceptual and visual-motor deficit. Analysis of the data indicated that, as expected, the clumsy children with learning disabilities scored significantly lower than the children without learning disabilities (the control group). There was no significant difference between the clumsy and non-clumsy children with learning disabilities or between the non-clumsy children with learning disabilities and the control group. Degree of clumsiness significantly correlated with scores on four of five tests. Results are discussed in terms of subtypes of learning disabilities and sample size.

Edition employed: TOMI (1984).

Reason for using the test: To sub-divide a group of children with learning difficulties into a 'clumsy' and 'non clumsy' group. To confirm that the control children were well coordinated.

Sample characteristics and control procedures: Children aged 5-8 years attending public and private schools within the Greater Boston, Massachusetts area. Index group (n=22): (16 boys, 6 girls) age range 5-8.10. All had a diagnosed learning disability and were receiving special services for their specific disability. Subdivided into two groups on the basis of TOMI scores: 'Clumsy' group (n=13) with TOMI scores of 4+. Mean age = 83.92 months (SD: 12.28). 'Non-clumsy' group (n=9) with scores of 0-3.5. Mean age = 85.00 months (SD: 13.87). Control group (n=22): (3 subjects had TOMI scores of 4-5.5, the rest scored 0-3.5). All in an age-appropriate grade, had no special education requirements and no history of receiving remedial help. Matched with index group on gender and age. Mean age = 85.50 months (SD: 14.85, Range: 5,6-8,11).

TEST DATA: 'Clumsy' group mean total score = 7.96 (SD: 2.23), 'Non-clumsy' group mean total score = 2.28 (SD: 1.12), Control group mean total score = 1.87 (SD: 1.49). Within the index group (n=22), Spearman rank order coefficiencts of correlation revealed significant correlations (p<.05) between TOMI scores and a visual perceptual test (Raven Progressive Matrices, -.395) and TOMI and two of three visual-motor tests (Visual Motor Integration, -.400; WISC-R Block Design, -.407). A point-biserial correlation between TOMI scores and scores on the Primary Visual Motor Test was also significant (r=-.44).

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Piek, J.P. and Coleman-Carman, R. (1994).

Kinaesthetic sensitivity and motor performance of children with developmental coordination disorder.

Developmental Medicine and Child Neurology, 37, 976-984.

Summary
Earlier research has demonstrated a number of variables contributing to motor coordination problems (clumsiness) in children. The present study examined the contribution of kinaesthetic sensitivity in determining the level of motor coordination in children. 20 children with significant movement problems were compared with 20 control children matched for age, gender and Verbal IQ. The kinaesthetic perception and memory test from Laszlo and Bairstow's Kinaesthetic Sensitivity test was a powerful measure for distinguishing clumsy from control children. The authors' passive kinaesthetic acuity test did not distinguish the two groups, but did so when administered actively. These results indicate that future research on clumsiness in children should involve more complex tasks, as problems associated with the central translation processes may cause the coordination difficulties seen in clumsy children.
Edition employed: Movement ABC (1992).
Reason for using the test: To obtain an objective measure of motor impairment/ competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: 40 children aged 8-12 years. All had at least low-average Verbal IQ (using the short form of the WISC-III) and no known neurological or physical disorders (according to information from a parent questionnaire). Index group (n=20): mean age = 9.15 years (SD: 1.23), mean Verbal IQ = 105.45 (SD: 10.56), mean Performance IQ= 99.8 (SD: 21.24). Recruited through local schools, community newspapers or remedial movement programs throughout Perth, Western Australia. All in 20th centile on Movement ABC. Control group (n=20): mean age = 9.05 years (SD: 1.19), mean Verbal IQ = 113.40 (SD: 17.19), mean Performance IQ = 121.00 (SD: 17.19). Recruited through primary schools to match the index group for age (within 6 months) and gender. All were above the 25th centile on the Movement ABC. There were no significant difference between the groups on Verbal IQ ($t(1,38)=2.6$, $p>0.05$), but there were significant differences between the groups on Performance IQ ($t(1,38) = 11.6$, $p<0.005$).
TEST DATA: Index group mean = 19.30 (SD: 7.67), Control group mean = 2.88 (SD: 1.57). Index group scores were significantly higher than the control group ($t(1,38)=64.98$, $p<0.001$). A significant positive correlation was found between kinaesthetic perception and memory and total Movement ABC scores ($r=0.80$, $p<0.001$). Movement ABC scores were not found to have a significant relationship with kinaesthetic acuity total ($r=-0.31$, $p>0.01$) or kinaesthetic acuity active ($r=-0.39$, $p>0.01$) scores. Multiple regression analyses showed that 67% ($R^2 = 0.67$) of the variance in Movement ABC scores was predicted by all of the independent variables as a group ($F(5,34) = 14.10$, $p<0.001$). Post hoc analyses revealed significant predictive power for the perception and memory variable only ($t(5,34) = 5.74$, $p<0.001$). There was a significant negative correlation between Performance IQ and Movement ABC scores ($r=-0.54$, $p<0.001$) but this was not significant in terms of predicting movement ability.
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Robinson, R.J. (1991).

Causes and associations of severe and persistent specific speech and language disorders in children.

Developmental Medicine and Child Neurology, 33, 943-962.

Summary
Eighty-two school-age children with severe and persistent specific speech and language disorders were studied. 71 had specific developmental language disorders, three had structural malformations (cleft palate) and eight had disorders acquired after a period of normal language development, including five with Landau-Kleffner syndrome. The sex ratio was 3.8 boys to one girl. Nearly half had a family history of speech-language disorder, with one in 5.2 affected siblings. Aetiological factors were found in 26 per cent: 11 per cent prenatal, 3 per cent perinatal and 12 per cent postnatal. 21 per cent had had a seizure and 7 per cent had had seizures after the age of eight. 29 per cent were left-handed, 90 per cent were clumsy and 22 per cent first walked after 18 months. The complex origins of specific speech and language disorders are discussed.

Edition employed: TOMI (1984).
Reason for using the test: To assess motor impairment/competence in children with severe specific speech and language disorders.
Sample characteristics: The entire population of a residential school in Surrey, England. 71(59 boys, 12 girls) of 82 children aged 8-16 years were tested. All had severe specific disorders of speech and language. Non-verbal IQ mean score = 101.0 (SD: 10.3).
TEST DATA: 64 children had total scores of 6 or more. Total score mean for boys = 20.6 (SD: 13.1), total score mean for girls = 25.7 (SD:13.0). Total scores obtained are above the maximum for any one age level because children were tested at younger age levels until some items were passed. Clumsiness correlated with a history of late walking and also with lower non-verbal IQ.
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Schoemaker, M.M. & Kalverboer, A.F. (1994).

Social and affective problems of children who are clumsy: How early do they begin?

Adapted Physical Activity Quarterly, 11(2), 130-140.

Summary
The purpose of this study was to examine the social and affective concomitants of clumsiness in children. The results suggest that children who are clumsy are more introverted than children without movement problems, judge themselves to be less competent both physically and socially, and are significantly more anxious. However, when the relationship between severity of clumsiness and social or affective problems was investigated, only socially negative behaviour was shown to be less common in the children who were most severely clumsy. Although some patterns were detected among social and affective problems, the overall picture was rather heterogeneous. The implications of the results for development and intervention are discussed.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Children aged 6-9 years from mainstream schools. IQs assumed to be in the normal range. Index group (n=18, 15 boys, 3 girls): A two step selection procedure was adopted. Children were first selected by the school doctor in the school medical examination if they scored poorly on one or more of the following items: walking, walking on heels or toes, hopping, walking on a line, The Romberg test, drawing, finger opposition, diadochokinesis, finger-nose test, ball catching. Secondly, children were included if their score on the TOMI fell in the bottom 5%. None showed evidence of a gross neurological disorder. Mean age = 7,4 (Range: 6.1-9.0). Control group (n=18): matched for age and gender to children in the index group. All had a total score of below 4.5 on the TOMI. Mean age = 7,4 (Range: 6.0-9.1).
TEST DATA: Index group mean total score = 8.1 (SD: 2.8), Control group mean = 1.6 (SD: 1.2). The difference between the groups was statistically significant for the total scores ($p<.01$) and for each item. Spearman rho correlations between total TOMI scores and measures of social and affective functioning in the index group revealed that except for socially negative behaviour (Groningen Behavioral Checklist – School situation) no other aspect of social or affective functioning was specifically related to severity of clumsiness. Signs of socially negative behavior were less common in the children who were most severely clumsy ($r=-.49$, $p=.02$). This is in contrast to the control group, where a significant positive relationship between TOMI scores and signs of socially negative behavior was found ($r=.65$, $p<.001$). A logistic regression analysis revealed a subset of four variables to be a good predictor of clumsiness: introversion, socially negative behaviour, perceived physical competence and positive task orientation.

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Pattern drawing by clumsy children: A problem of movement control?

In M.L. Simner, W. Hulstijn & P.L. Girouard (Eds) *Contemporary issues in the forensic, developmental and neurological aspects of handwriting*. Vol. 1. Toronto: Association of Forensic Document Examiners, pp45-64.

Summary
Clumsy children frequently have problems executing a number of fine as well as gross motor behaviours in daily life. Research thus far, however, has only addressed the problems these children have with discrete, goal-directed behaviours. The present study was concerned with the problems that clumsy children have when asked to perform a complex motor task that required the execution of certain behaviours which are basic to the act of handwriting. While the outcome of this work revealed no differences between clumsy and control children in preparation time prior to performing the task, important differences were found in the execution of the motor behaviours themselves. In particular, clumsy children were slower, less accurate and less fluent when compared to control children. Discussion focuses on the bearing these findings have for our understanding of the processes that clumsy children may employ when they engage in handwriting.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/ competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Index group: n=16 (14 boys, 2 girls). Age range: 6.1-9.0 years (mean = 7.4). Identified during the routine medical examination by a school physician. All attended mainstream school and none displayed evidence of a neurological disorder. Control group: n=16. Age range: 6.0-9.1 years (mean = 7.4). Selected by school physicians and matched for age and sex to children in the index group.
TEST DATA: Mean total score: Index group = 8.1, Control group = <4.5
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Sugden, D.A. & Wann, C. (1987).

The assessment of motor impairment in children with moderate learning difficulties.

British Journal of Educational Psychology, 57, 225-236.

Summary
Two tests of motor behaviour examined the performance of 8-and 12-year-old children with moderate learning difficulties. On the Test of Motor Impairment 50 per cent of 8 year-olds and 29 per cent of 12-year-olds had motor problems as compared to 5 per cent in a normal population. The Test of Kinaesthetic Sensitivity assessed the kinaesthetic abilities of children, possibly offering explanations for the children's poor performance. On the Kinaesthetic Acuity test only seven out of 61 children reached the mean level score from the normative data, while on the Kinaesthetic Memory test 18 reached this level. There was a variable relationship between the two tests. The children who failed the Test of Motor Impairment did have poorer scores on both parts of the Test of Kinaesthetic Sensitivity, but the difference between these and the scores of the children who passed was not great enough to be predictive.
Edition employed: TOMI (1984).When a child did not pass at his/her own age level, they were tested at subsequently lower age levels until a pass was obtained.

Reason for using the test: To assess the prevalence and nature of motor difficulties in children with moderate learning difficulties and to evaluate the appropriateness of the test with this population.
Sample characteristics: Selected from special schools all had moderate learning difficulties. Eight-year-old group: n=30 (9 girls, 21 boys). Mean age 8, 4 (SD: 5.5m, Range: 7,3-8,11). Twelve-year-old group: n=31(15 girls, 16 boys). Mean age 12,6 (SD: 5.8m, Range: 11,3-12,11). IQ information: 8-year-old group: Mean = 63 (SD: 7.5, Range: 50-75). 12-year-old group mean = 65.2 (SD: 7.7, Range: 46-77). The Test of Kinaesthetic Sensitivity, KST (Laszlo & Bairstow, 1985) was also employed.
TEST DATA: 50% of 8-year-olds and 29% of 12-year-olds scored 6+ (impairment category) compared to 5% in the TOMI normative sample. 20% of 8-year-olds and 39% of 12-year-olds scored 0-1.5 compared to 60% in the TOMI normative sample. 33% of 8-year-old group and 19% of 12-year-old group performed at least two years below their chronological age. 50% of 8-year-olds and 79% of 12-year-olds performed at their own age level, with 33% of 8-year-olds and 33% of 12-year-olds performing at least 2 years below. There was great within-group variability. For those children that failed at their own age level, the problems for the 8-year-olds were consistent across the three subtests. For the 12-year-olds, manual dexterity was less of a problem than the other two sections. In an item by item analysis, means for the index children were nearly always poorer than the normative sample. Relationship between TOMI and KST performance: No correlations between the TOMI and the KST items reached statistical significance, both using total TOMI scores and raw scores for individual items. Looking at the number of children passing or failing both tests, the relationship between the two was variable and not very strong. Children who failed the TOMI did have poorer scores on both parts of the KST but the differences were not great enough to be predictive, partly because scores on the KST were so low.
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Van der Meulen, J.H.P., van der Gon, J.J., Gielen, C.C.A.M., Gooskens, R.H.J.M. & Willemse, J. (1991).

Visuomotor performance of normal and clumsy children. I: Fast goal-directed arm-movements with and without visual feedback.

Developmental Medicine and Child Neurology, 33, 40-54.

Summary
The mechanisms underlying accuracy in fast goal-directed arm-movements were investigated in normal and clumsy children in two age-groups, six to seven and ten to eleven years. Clumsy children in both age-groups had a longer movement time than normal children; this difference increased slightly when there was visual feedback. For both normal and clumsy children, the relative variability of the total distance moved was smaller than that of the distance moved during acceleration, indicating a variability reduction mechanism in the course of a movement. In the six-to seven-year-old group, the relative variability of the distance moved during acceleration and of the total distance was larger for clumsy than for normal children; this did not reach significance in the older group. It is suggested that motor difficulties are linked to inaccuracy in open-loop control processes and to less efficient use of visual feedback.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.
Sample characteristics and control procedures: Children aged 6-7 and 10-11 years from a medium-sized provincial town in the Netherlands. Index group: 6-7 years (n=12), 10-11 years (n=14, 10 boys, 4 girls). Scores on the Groningen Motor Observation Scale (GMO, van Dellen, 1987) by class teachers lay in the upper 10% of the distribution of scores within the classroom. TOMI score ≥ 3.5. Mean age 6-7 group = 86 months (SD: 8 months), mean age 10-11 group = 133 months (SD: 6 months). Control group: 6-7 years (n=16), 10-11 years

(n=14). Scores on the GMO lay in the lower 50% of the distribution within the classroom. TOMI score ≤1.5. Mean age 6-7 group = 87 months (SD: 6 months), mean age 10-11 group = 131 months (SD: 5 months). Individually selected to match the index children for age and gender. VIQ and PIQ scores were within the normal range (all around 110) with no significant differences between the index and control groups, except for lower PIQ in index 10-11 year old group (p<.005).

TEST DATA: Total scores: 6-7 year olds. Index group mean = 5.1 (SD: 1.5). Control group mean = 0.6 (SD: 0.6). 10-11 year olds. Index group mean = 5.1 (SD: 1.6). Control group mean = 0.8 (SD: 0.5). Percentage agreement between the TOMI and the GMO was 64% for the 6-7 year olds and 65% for the 10-11 year olds.

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Visuomotor performance of normal and clumsy children. II: Arm-tracking with and without visual feedback.

Developmental Medicine and Child Neurology, 33, 118-129.

Summary
Tracking performance was investigated in normal and clumsy children in two age-groups, six to seven and ten to eleven years. Target signals moving unpredictably along a straight line had to be tracked, both with and without visual feedback. Performance was described in three ways: (1) performance in the low-frequency range; (2) the delay between target signal and tracking movement; and (3) a measure of tracking quality or over-all similarity in the shape of target signal and tracking movement. Clumsy children in both age-groups had a lower tracking quality and longer delay than the normal children. Disturbances in the regulation of attention seemed to affect tracking performance, particularly of the six- to seven-year-old clumsy children. There was no significant difference between normal and clumsy children in the effect of visual feedback on tracking performance. This suggests that clumsiness is not linked to disturbance of the integration of visual feedback information and motor processes.

Edition employed: TOMI (1984).

Reason for using the test: To obtain an objective measure of motor impairment/competence. To quantify the extent of movement difficulties of children in the index group and to confirm that the control children were well coordinated.

Sample characteristics and control procedures: Children aged 6-7 and 10-11 years from a medium-sized provincial town in the Netherlands. Index group: 6-7 years (n=13), 10-11 years (n=14, 10 boys, 4 girls). Scores on the Groningen Motor Observation Scale (GMO, Van Dellen, 1987) by class teachers lay in the upper 10% of the distribution within the classroom. TOMI score ≥ 3.5. Mean age 6-7 group = 86 months (SD: 7 months), mean age 10-11 group = 133 months (SD: 6 months). Control group: 6-7 years (n=16), 10-11 years (n=14). Scores on the GMO lay in the lower 50% of the classroom distribution. TOMI score ≤1.5. Mean age 6-7 group = 87 months (SD: 6 months), mean age 10-11 group = 131 months (SD: 5 months). Individually selected to match the index children for age and gender. VIQ and PIQ scores were within the normal range (around 110) with no significant differences between the index and control groups, except for lower PIQ in the index 10-11 year old group (p<.005).

TEST DATA: Total scores: 6-7 year olds. Index group mean = 5.2 (SD: 1.5). Control group mean = 0.6 (SD: 0.6). 10-11 year olds. Index group mean = 5.1 (SD: 1.6). Control group mean = 0.8 (SD: 0.5).

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Wright, H.C. & Sugden, D.A. (1996).

The nature of developmental coordination disorder: Inter- and intra-group differences.

Adapted Physical Activity Quarterly, 13, 357-371.

Summary
The nature of developmental coordination disorder (DCD) was investigated in a selected group of Singaporean children aged 6-9 years using two methods: an inter-group comparison of children with DCD and matched controls (n=69) and an intra-group study on the same children with DCD in the search for subtypes within this group. The results from the two approaches demonstrate that while the children with DCD are clearly different from the control subjects, the difficulties seen within the DCD group are not common to all the children. Four identifiable subtypes were found within the children with DCD. This more specific information gained about the difficulties children with DCD experience is not easily established from the inter-group analysis, suggesting that the design of future intervention studies should incorporate differences found in subtypes of children with DCD.
Edition employed and profession of testers: Movement ABC (1992) Test and Checklist. A qualified Physical Education teacher administered the Test. The Checklist was completed by class teachers.
Reason for using the test: To identify children with DCD and to examine differences between these children.
Sample characteristics and control procedures: 427 children from twenty four schools from four zones in Singapore: 102 six year olds (48 boys, 54 girls), 115 seven year olds (58 boys, 57 girls) 97 eight year olds (46 boys, 51 girls) and 113 nine year olds (57 boys, 56 girls). All children were assigned to either the index (DCD) or control group depending on their results from the Checklist. Index group (n=69, 39 boys, 30 girls): divided into 'Movement Problem' group (MP, n=26) scoring below 5% cut off and 'At Risk' group (AR, n=43) scoring between 5-15% on the Western norms. Control group (n=69): scored above the 15% cutoff point. Control and index children were matched pairwise, being of the same gender and age and in the same classroom.
TEST DATA:
Differences between index and control groups. The index group had significantly higher scores than controls on the total Test ($F(1,136) = 16.86$, $p<.001$) and on manual dexterity ($F(1.126) = 11.01$, $p<.001$), ball skills ($f=(1.126) = 6.15$, $p<.05$) and balance ($F(1,126) = 6.52$, $p<.05$). In each age group the index children had higher mean scores than their matched controls. The greatest differences were for 7 and 8-year olds and controls in manual dexterity and ball skills. Stepwise discriminant function analyses was used to detect variables from the Test and Checklist that discriminated children from the index group and controls. Sections 1-4 of the Checklist combined to form a single discriminant function, which correctly classified 86% of the index children. In the Test, the manual dexterity section formed the discriminant function, with 60% of the children correctly classified. ($F(2,96) = 42.67$, $p<.0001$). Section 4 of the Checklist and the Manual Dexterity section of the Test had the greatest discriminatory power ($F(1,97) = 65.99$, $p<.0001$). 81% of the index children were correctly classified using scores from section 4 of the Checklist, 50% from the manual dexterity section of the Test.
Index group. A factor analysis was first conducted on the 8 items from the Test and 4 sections from the Checklist. Five factors with an eigen value over 1 emerged. They were named 'Fast Hands', 'Catching', Changing Environment', 'Dynamic Balance' and 'Control of Self' and explained 16.0%, 15.6%, 14.2%, 7.4% and 6.5% of the variance respectively. These five variables were then used in a cluster analysis. Four clusters were determined. Cluster 1 (n=42) showed an even profile and seemed the least impaired, Cluster 2 (n=10) had particular difficulties with catching, Cluster 3 (n=12) had difficulties in tasks where the environment is changing, Cluster 4 (n=5) had particular difficulties when manipulating the hands at speed.
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Wright, H.C. & Sugden, D.A. (1996).

A two-step procedure for the identification of children with Developmental Co-ordination Disorder in Singapore.

Developmental Medicine and Child Neurology, 38, 1099-1105

Summary
The prevalence of Developmental Coordination Disorder (DCD) among 6 to 9-year-old Singaporean primary school children was studied from a random sample (N=427) through a two-step identification procedure contained within the Movement ABC. The prevalence rate from this two step procedure was 4% when the first step included the bottom 15% of the random sample. The two-step procedure moves towards fulfilling the diagnostic criteria for DCD set out by the American Psychiatric Association (DSM-IV) and the World Health Organization (ICD-10) of a serious motor impairment in the development of motor coordination and significant interference with the activities of daily living not due to mental retardation or a known physical disability.
Edition employed: Movement ABC (1992) Test and Checklist.
Reason for using the test: To identify children with DCD to ascertain the prevalence of DCD in Singaporean children. To compare the results of Singaporean children on the standardized test with those of American children used in the standardisation sample. To compare the results of Singaporean children on the Checklist with those from the U.K. standardisation sample. To investigate the reliability of the Checklist.
Sample characteristics: 427 children (102 6-year olds, 115 7-year olds, 97 8-year olds and 113 9-year olds) from 24 primary schools across the four zones of Singapore, randomly selected from class lists. For 103 of the children, two Checklists were completed by the same teacher to obtain a measure of reliability. Index children (n=64): were taken as those who scored below the 15th percentile on the checklist. Control children (n=64): were selected as those scoring above the 15th percentile on the Checklist, matched for age, sex and class. These two groups were also tested on the Movement ABC.
TEST DATA: Checklist. Checklist Reliability: boys aged 7, r=.92, girls aged 7, r=.93, boys aged 8, r=.94, girls aged 8, r=.50 (all significant at .01 except for girls aged 8, where there was a low range of scores). Checklist results: Overall, 10.1% scored below 15th percentile, 6.1% below 10th percentile but there was great variation in the age groups, with a greater prevalence of DCD with increasing age. An ANOVA with repeated measures on the section scores showed a main effect for section scores ($F=112, 76$, $df=3, 1257$, $p<.001$). Post hoc analyses revealed that scores increased from section 1 to section 4. There were significant main effects for age ($F=6.44$, $df=1, 419$, $p<.001$) and gender ($F=6.44$, $df=1, 419$, $p<.01$). There were also a number of significant interactions. Post hoc analyses revealed that the 6 year olds were significantly different from all other ages ($p<.01$). Results for the 7 and 8 year olds on section 3 was significantly different to that of the 8 and 9 year olds. Boys were worse than girls in sections 1 and 2 ($p<.01$) and section 4 ($p<.05$) but not in section 3. In section 5 an ANOVA revealed main effects for age ($F=4.58$, $df=3, 419$, $p<.01$) and gender ($F=17.12$, $df=1, 419$, $p<.001$). Boys had more difficulty in this section than girls and 6 year olds more difficulty than 7 year olds. Pearson product moment correlation showed a moderately strong relation between section 5 and sections 1-4 ($.48$, $p<.01$).
Test. Overall and in each age group, those who scored below the 15th percentile on the Checklist performed more poorly on the test than those who scored above the 15^{th} percentile on the Checklist. This was significant overall ($p<.001$) and in 6, 7 and 8 year olds ($p<.05$) but not in 9 year olds ($p=.08$). Of the 64 identified by the Checklist, 17 of these also scored below the 15th percentile on the Test.
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This paper is also relevant to Section Four.

Section 2 Longitudinal Studies

Until quite recently, the prognosis for children identified in their early years as being deficient in the acquisition of movement skills was assumed to be benign. The widely held belief that children spontaneously "grow out of" their coordination difficulties conjured up a reassuring picture of reliable and autonomous recovery processes gathering up the lagging or deviant children and hastening them back into the fold of normality. However, a growing number of longitudinal studies show that this view is no longer tenable. The majority of children with motor difficulties do not simply "grow out of" them. Furthermore, many develop serious educational, social or emotional problems as they progress through school.

The *TOMI/Movement ABC* have been used in three distinct types of longitudinal investigation. The first category embraces children regarded as being "at risk" in the neonatal period due to various reasons including prematurity or low birth weight. Whilst, in earlier times, many of these children would not have survived, improvements in neonatal care through the 1970's and 1980's have led to dramatically increased survival rates. The negative aspect of this achievement, however, has been the elevated incidence of disability amongst these survivors. Some have motor difficulties of a severity that unambiguously attracts the diagnosis "cerebral palsy". Others present with more subtle difficulties that require investigation by formal normative tests.

Only one or two studies of this sort which have employed the *TOMI/ Movement ABC* have carried the monitoring of development beyond primary school age. Nevertheless, the consensus is impressive in that all have found persistence of motor difficulties to be common. In the large scale studies, the number of index children ranges from 60 to 183. Some have also included matched controls. A few studies have chosen to concentrate upon groups of children, which, while necessarily small in number and therefore not generally representative, are of peculiar interest, e.g. Marlowe et al.'s (1990) study of sextuplets. Where there has been more than one follow up of a particular cohort of children we have indicated this (e.g. results from the same cohort reported in Marlow et al., 1989; 1993 and Powls et al., 1995).

Advances in technology have revealed, in increasingly fine detail, brain damage associated with prematurity. Not surprisingly, an increasing number of studies focus on the relationships between these lesions, whether enduringly detectable or not, and later outcome. For example, the availability of ultrasound scans repeated at regular intervals over a two week period for all two hundred children in the cohort made possible Dubowitz, Henderson and Jongmans detailed studies of the relationship between type and severity of lesion and later motor competence.

The second category in this section consists of studies of children with movement difficulties identified when they start school (in most countries between the ages of five and seven). These samples of children may loosely be regarded as drawn from the populations labeled DCD or SDDMF, although few of the studies attempt to apply the criteria governing the use of these labels. For example, motor status is often determined by teacher rating or a non-standardized assessment. Like studies in the previous category, every investigation of this type conducted to date shows enduring motor problems, which in some cases have been pursued as far as young adulthood. However, the exact proportion varies from study to study and no one has yet been able to identify the variables which affect the trajectory of an individual child's motor development.

In the third category, the focus of attention changes to children who suffer from clearly identifiable medical conditions such as epilepsy (Beckung et al., 1994) and hydrocephalus (Fernell et al., 1988). Here, the *TOMI/Movement ABC* has mainly been used to determine prognosis in the motor domain. However, in the case of Congenial Hypothyroidism, a much more specific question concerning the effect of variation in treatment onset is also addressed.

One difficulty which faces those concerned with long term prognosis in these groups of children is the absence

of standardized tests with normative data extending beyond 12 years of age. This is true not only of the *TOMI/Movement ABC* but of all other standardized perceptuo-motor tests. These difficulties can be illustrated by the ten year follow-up study reported by Losse et al (1991). In this study, we were obliged to test 16 and 17 year olds on the age band designed for use with 11 and 12 year olds. While the difference between the groups in this case was large enough to be captured by test items designed for use with much younger children, this will not always be so and the general situation is unsatisfactory. Therefore, with a small group of colleagues in The Netherlands, Finland and Switzerland we have been endeavoring to discover what changes have to be made to the tasks to give them adequate sensitivity for those in the age range 13 to 18. Some items from this new age band have already been employed in two recent studies following up children into early adulthood (Cantell et al, 1994, Geuze & Börger, 1994).

Beckung, E., Uvebrant, P., Hedström, A. & Rydenhag, B. (1994).

The effects of epilepsy surgery on the sensorimotor function of children.

Developmental Medicine and Child Neurology, 36, 893-901.

Summary
The motor and sensory functions of 50 children were investigated before and six months after epilepsy surgery; 34 infants were assessed 24 months after surgery. Post-operatively, 20 children were seizure-free and 22 had a significant reduction of seizures. Epilepsy surgery was found to be an effective mode of treatment for intractable seizures in childhood, even in multiply handicapped individuals. Motor and sensory functions did not deteriorate after surgery; in fact, significant improvements were found in more than half of the children, including those with multiple handicaps. Improvements were most obvious in the seizure-free group, but were also noted in those with reduced seizure frequency. The younger children benefited more from surgery as regards sensorimotor function than did older children and adolescents.
Edition employed: TOMI (1984). Only four items employed**.**
Reason for using the test: To assess change in motor impairment/competence after surgery for epilepsy.
Sample characteristics: 50 children aged 8 months to 21 years with severe intractable epilepsy consecutively referred to the Epilepsy Surgery Programme at the Department of Paediatrics, Ostra Hospital, Gothenburg. All had surgery consisting of hemispherectomy (n=6), anterior callosotomy (n=6), lobectomy (n=16) and local resections (n=22). Assessed in 1988-93. Median age at surgery was 11 years. They were divided into subgroups according to their additional impairments: (1) Epilepsy without neurodeficits (n=14), (2) Epilepsy and Cerebral Palsy or other major movement disorders (n=10), (3) Epilepsy and Mental Retardation (n=17), (4) Epilepsy, Cerebral Palsy and Mental Retardation (n=9).
TEST DATA: Since only four test items were incorporated into a much larger battery, little useful data on the test as a whole emerge from this study.
Correspondence to:
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Bouza, H., Dubowitz, L.M.S., Rutherford, M., Cowan, F. & Pennock, J.M. (1994).

Late magnetic resonance imaging and clinical findings in neonates with unilateral lesions on cranial ultrasound.

Developmental Medicine and Child Neurology, 36, 951-964.

Summary
Twenty-two neonates (11 term and 11 preterm) with predominantly unilateral hemispheric lesions on ultrasound were re-examined clinically and by magnetic resonance imaging (MRI) at between two and nine years of age. The aim was to correlate early ultrasound and late MRI findings with the development of hemiplegia. At follow-up, five children were normal and 15 had hemiplegia, which was mild in seven and moderate in 10. The presence or absence of hemiplegia, or its severity, could not be predicted from either early ultrasound or later MRI appearances.
Edition employed: Movement ABC (1992).

Reason for using the test: To assess motor impairment/competence of children born with predominantly unilateral hemispheric lesions.
Sample characteristics: 22 children (8 boys, 14 girls) aged 2-9 years. All but one was born at the Hammersmith or Queen Charlotte's and Chelsea Hospitals, London, or had been referred within 48 hours of birth. Born at term (n=11) or preterm (n=11) with predominantly unilateral haemorrhagic or ischaemic lesions diagnosed pre- or peri-natally with ultrasound. All had a clinical examination and MRI scan performed after two years of age. Only older children were tested on the *Movement ABC*.
TEST DATA: No individual or group figures provided.
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Department of Pediatrics and Neonatal Medicine, Hammersmith Hospital, Du Cane Road, London, W12 OHS, UK.

Cantell, M.H., Smyth, M.M. & Ahonen, T.P. (1994).

Clumsiness in adolescence: Educational, motor, and social outcomes of motor delay detected at 5 years.

Adapted Physical Activity Quarterly, 11(2), 115-129.

Summary
This paper reports the follow-up, at age 15, of a group of children who were diagnosed at age 5 as having delayed motor development. The group of children who were clumsy and the control group still differed in motor performance 10 years later: 46% of the members of the early motor delay group were classified as different from the control group on motor and perceptual tasks. The remainder made up an intermediate group that could not be clearly distinguished from the other groups. Adolescents with stable motor problems had fewer social hobbies and pastimes and had lower academic ambitions for their future than the controls, although the lower academic ambitions also reflect their lower academic achievements. The adolescents who were clumsy believed they were less physically and scholastically competent than the controls. However, they did not have poor opinions of their social acceptance or self-worth. The intermediate group, although they showed motor delay at age 5, had good school performance and high ambitions and engaged in social sports at age 15.
Edition employed and profession of tester: An experimental version, Age Band 5, of the TOMI 1984 for children aged over 12 years. Five tasks were employed: ball catch, ball throw, jump and clap, static balance, dynamic balance.
Reason for using the test: To assess motor impairment/competence in two groups of 15 year old children: those identified as having delayed motor development at age 5 and matched controls.
Sample characteristics: Finnish children aged 15 years. Index group (n=81): From screening of total population of 5 year olds in one Finnish town, identified as having delayed motor development at age 5. Motor development was still delayed at age 7 but none had cerebral palsy and all had IQs in the normal range (from the Finnish version of the short form WISC-R). Control group (n=34): One control child was selected for every third index child at age 7, matched for school, class, age and gender. Mean IQ at age 7 was lower in the index group (103 vs 119). All children were reassessed at the age of 9, 11 and 15 years. The five tasks from the *TOMI* were included in a battery of 14 other perceptual-motor and perceptual tasks. The index subjects were categorised as 'stable clumsy' (n=37) at age 15 if they either (1) scored 4.5 standard deviations (SD) below the control mean on one of the tasks administered (2) scored 2.5 SD below on three tasks or (3) scored 1.5 SD below on five tasks. The remaining index subjects were categorised as 'intermediate' (n=44). The 'stable clumsy' group had significantly lower scores on each of the WISC-R sub tests than either the 'intermediate' or the control group ($p<.05$) who did not themselves differ.
Results: For each task, the 'stable clumsy' group performed significantly more poorly than both the 'intermediate' group and the control group. The mean scores for the five tasks for the 'stable clumsy', 'intermediate' and control groups respectively were: Ball catching (no. catches out of 10) 11.70, 15.36, 17.00 (df 2, 112; F=16.50). Ball Throwing (no. hits out of 10) 5.46, 6.61, 7.24 (F=6.79). Jump and clap (no.claps) 2.49, 3.19, 3.26 (F= 19.66). Static balance (max 20 secs.) 8.52, 14.90, 19.07 (F=13.65). Dynamic balance (no. steps up to 15) 10.22, 14.12, 14.00 (F=19.20).

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Fernell, E., Hagberg, B., Hagberg, G., Hult, G. & von Wendt, L. (1988).

Epidemiology of infantile hydrocephalus in Sweden: A clinical follow-up study in children born at term.

Neuropediatrics, 19, 135-142.

Summary
The long-term outcome of infantile hydrocephalus (IH) in children born at term during a period of active shunt treatment was studied in a population-based survey. The cohort consisted of 68 children ≥ 6 years old and born in 1967-78 in the south-western Swedish health care region. The clinical follow-up included neuro-paediatric assessment, the TOMI, the WISC test, CT and EEG analyses. Nineteen of the 68 children (28%) had cerebral palsy, 17 (25%) minor motor dysfunction and 32 (47%) no motor dysfunction; mental retardation was present in 26 (38%), 16 with an IQ 50-70 and 10 with IQ < 50; 42 children (62%) had normal intelligence and epilepsy was found in 15 (22%). Compared with a non-shunted IH series from the 1950s, the survival of IH children had considerably increased. Of constituents characterizing the IH cohort from the time prior to shunting, ataxia, divergent squint and the special "Cocktail-party behaviour" had significantly decreased, all of which are highly related to chronic expansion of the ventricular system. The frequencies of other impairments such as mental retardation and epilepsy were fairly similar, reflecting the present increased survival of IH children with primarily non-IH-dependent brain damage. IH cohort with associated brain parenchymal defects had the poorest outcome, and those without had in general a much more favourable one. Thus the single most important factor for the outcome of IH was found to be the presence or absence of associated primary brain damage or maldevelopment.
Edition employed: TOMI (1984).
Reason for using the test: To obtain an objective measure of motor impairment/competence in children with Infantile Hydrocephalus (IH).
Sample characteristics: Index group (n=68, 40 boys, 28 girls): aged 6-17 years (mean age = 11.25 years). All had IH and were born between 1967-78 in the south-western health care region of Sweden. 90% (n=61) had had an intraventricular shunt inserted at median age of 2.3 months (range: 1 day-5.9 years). Control group (n=149): randomly selected from school children in ordinary classes in Gothenburg, Sweden.
TEST DATA: For shunted children in the index group, excluding those children with cerebral palsy, minor motor dysfunction and mental retardation, performance on the test was significantly worse than controls ($p<.001$). Half of the children in the index group had moderate or definite impaired motor ability compared to 14% among controls.
Correspondence to:
B. Hagberg
Department of Paediatrics II, East Hospital, S-41685 Gothenburg, Sweden.

Forslund, M. (1992).

Growth and motor performance in preterm children at 8 years of age.

Acta Paediatrica, 81, 840-842.

Summary
At 8 years of age 41 preterm and 24 term children were followed up in a long-term prospective study of 46 unselected infants born before 35 completed weeks of gestation and of 26 term infants. The two groups were comparable in physical growth and there was no significant difference between them in motor performance, as evaluated with the Test of Motor Impairment. Only minor motor problems were found (in 22% of the preterm and 17% of the term group). In the preterm group, motor impairment was correlated with birth weight. The preterm children had less developed postural control and manifested more compensatory movements during the balance tasks than the term children.

Edition employed and profession of tester: TOMI (1984). Administered by a physiotherapist. The two observation checklists of the test were also completed (Faults of Motor Control and Faults of Coping Style).
Reason for using the test: To assess and compare motor impairment/competence in children born preterm and controls.
Sample characteristics and control procedures: Swedish children aged 8 years. Index group (n=41): born preterm (gestational age < 35 weeks). Control group (n=24): born full term.
TEST DATA: Group means are not provided. There were no significant differences between the groups on total or item scores. Nine (22%) of the preterm group and four (17%) of the term group scored 2-3.5 which the authors report indicates a possible presence of minor motor problems. One child in the preterm group was reported as having slight spastic diplegia and two as having minimal brain damage. These three children all scored 2 or more on the test. Birth weight was the only perinatal factor significantly correlated with total TOMI scores (Spearman's rank correlation $p<0.05$). Checklists: Group differences were small and not significant. Motor Control Faults – more than one notation was made for four children in the index group. A larger percentage of children in the index group exhibited compensatory movements of the arms and trunk in the balance tasks. Copying Style Faults – more than one notation was made for three index children. No faults were noted for the control group.
Correspondence to:
M. Forslund
Department of Paediatrics, University of Lund, Malmo General Hospital, Sweden.

Geuze, R.H. & Börger, H. (1993).

Children who are clumsy: Five years later.

Adapted Physical Activity Quarterly, 10, 10-21.

Summary
The aim of this follow-up study was to assess whether clumsiness persists beyond the age of 12 and to describe the characteristics of motor and other problems, if present. From 62 children studied in 1984, 12 clumsy and 14 control children were reassessed in 1989. Reasons for dropout were a change of address, unwillingness to participate, and exclusion of hyperactive children with clumsiness. The Test of Motor Impairment indicated that at least 50% of the clumsy children were still markedly below the level of normal motor performance. This outcome was also validated by parent and teacher opinions. Persistent problems were not specifically related to one domain of fine or gross motor ability or general coordination. Concomitant problems reported by teachers and parents were lack of concentration and problems in social behaviour.
Edition Employed: TOMI (1984) Age band 4 and an experimental version for children aged over 12 years.
Reason for using the test: To obtain an objective measure of motor impairment/ competence in children from a 'clumsy' and a control group.
Sample characteristics and control procedures: Children aged 11-17 years who had taken part in a study five years earlier when aged 6-12 years. In the original study children were selected for index and control groups on the basis of teachers opinions and scores on the TOMI. The two groups were originally matched for age, sex and school. IQ levels in the original index group were lower than controls for both performance and verbal tests, although all were in the normal range. Index group: n=12. Control group: n=14.
TEST DATA:
Comparison between 1984 *TOMI* score and 1989 age band 4 score: The mean *TOMI* score changed from 0.9 to 0.8 for the control group and from 5.9 to 3.7 for the index group. All but one of the original control children had a total score that remained within the normal range (0-3.5), one child scored in the borderline category (score=4). Half (6/12) of the original children classified as clumsy scored in the normal range at follow-up (0-3.5). Two still had serious motor problems (score>5.5) and four had borderline scores (score 4-5.5).
Comparison between 1984 *TOMI* score and 1989 experimental score: All but one of the original control children scored within the normal range (this was a different child to the one noted above). Three of the children from the original index group scored within the normal range, three borderline and six had serious motor problems. The

difference between the control and index group was significant (chi-squared, p<.01, df=2).
Comparison of age band 4 and experimental scores: On average, the total experimental TOMI score was higher than the TOMI age band 4 score. For the Index group the age band 4 and experimental scores were 3.7 and 5.4 and for the control group 0.8 and 1.9 respectively. This increase in scores was greater for the original index group.
Comparison of index and control groups at follow-up: Most test items from age band 4 and from the experimental version differentiated the two groups. The exceptions were, from age band 4: the static balance item and walking backwards and from the experimental version: piercing holes and walking backwards.
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Geuze, R.H. & Börger, H. (1994).

Response selection in clumsy children: Five years later.

Journal of Human Movement Studies, 27, 1-15.

Summary
The aim of this study was to determine whether a response selection problem, associated with clumsiness between the age of 7 and 12 years (Van Dellen and Geuze, 1988), persists beyond the age of 12. Assessment of the original groups (N=31) of clumsy and control children involved the Test of Motor Impairment and a 4-choice Reaction Time experiment on response selection. Originally clumsy children differed from the controls with respect to this particular stage of information processing. Five years later half of the children participated in further testing. About 50%-70% of the former clumsy children were still markedly below the level of motor performance of their matched peers (Geuze and Börger, 1993). The differences in response selection between the groups disappeared after 5 years, while both did improve their speed of performance. The authors conclude that slow response selection does not contribute to the problems of clumsiness beyond the age of twelve years.
Edition employed: An experimental version, Age Band 5, of the TOMI (1984) for children aged over 12 years.
Reason for using the test: To measure the degree of motor impairment/competence in children
Sample characteristics and control procedures: 11-17 year olds (mean = 14). Index group: n=11. Control group: n=13.
TEST DATA: Using preliminary cut off points determined in a small normative study, 4 index children scored in the normal range (0-3.5), 3 borderline (4-4.5) and 4 in the range indicating motor problems (6-9.5). All control children scored in the normal range. In each group, the correlation between TOMI scores and the slope of Reaction Time was only weakly positive and not significant.
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Hall, A., McLead, A., Counsell, C. Thomson, L. & Mutch, L. (1995).

School attainment, cognitive ability and motor function in a total Scottish very-low-birthweight population at eight years: A controlled study.

Developmental Medicine and Child Neurology, 37, 1037-1050.

Summary
The prevalence of learning problems and of cognitive and motor impairment in a total geographically based very-low-birthweight population (N=324) was compared at eight years of age with that in a population comprising two classroom peers, matched for gender and age (N=590). 15 per cent of those with extremely low birthweights

(ELBW), less than 1000g and 6 per cent of those with very low birthweights (VLBW), weighing 1000 to 1499g attended special schools. Index children in main-stream schools performed significantly less well in tests of neuromotor function than their comparison groups. Their mean IQs were 90.4 and 93.7 for those below and above 1000g. respectively, while their comparison groups' IQs were 102.5 and 101.2. In all cognitive subscales apart from that testing short-term auditory sequential memory, both index groups were less competent. They were also less able in Word Reading and Basic Number Skills. These children placed heavy demands on mainstream schools, with 52 per cent and 37 per cent of the index groups, respectively, requiring learning support compared with 16 per cent in both comparison groups.

Edition employed: Movement ABC (1992). 9-10 year Age Band using norms derived from the control population.

Reason for using the test: To assess motor impairment/competence and compare performance between children born of very-low-birthweight and controls.

Sample characteristics and control procedures: Index group (n=324): live-born infants born in Scotland in 1984 with birthweights less than 1500g. 24 attended special schools. Divided into a group with extremely low birthweight (ELBW), of <1000g and very low birthweight (VLBW), of 1000-1499g. Intelligence was assessed using the British Abilities Scales (BAS). ELBW (n=45) Mean IQ = 90.4, VLBW (n=255) Mean IQ = 93.7. Control group (n=590): identified by head teachers of the same sex, in the same class, who were nearest in birth date to the index child. In some smaller schools only one control was available. No appropriate controls were found for those index children attending special schools. Controls to ELBW group (n=90), Mean IQ = 102.5, controls to VLBW group (n=500), Mean IQ = 101.1.

TEST DATA: Excluding those children who were in special schools, both groups of LBW children performed less well overall than their comparison groups on the *Movement ABC*. This applied to all test items apart from throwing a beanbag into a box (both index groups), and shifting pegs with the non-preferred hand, for the VLBW index children only. All scores for individual items are reported. Girls in the total index and comparison groups were significantly worse at ball skills than boys, but in the ELBW population alone, there was no differences between boys and girls. No sex differences were found for any other test items nor in the overall scores.

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Henderson, S.E., Knight, E., Losse, A. & Jongmans, M. (1991).

The clumsy child in school – are we doing enough?

British Journal of Physical Education Research Supplement, 9, 2-8.

Summary
This paper presents a single case study of an intelligent child who was identified as having quite severe coordination problems early in life. She is not physically handicapped and has no known medical condition. The case study shows that her motor difficulties were noted throughout her school career both by her Physical Education teachers and others in the school. However, these difficulties were not seen as a "special educational need" and she received no additional help. Initially, the child's academic progress in school was well above average and she was universally popular with both adults and other children but as the years went by her early success was replaced by failure, depression and social isolation. The study forms part of a larger study investigating the long term prognosis for children who are "clumsy" and the educational implications of failing to recognise the need to help them.

Edition employed: TOMI (1972 and 1984).

Reason for using the test: To assess and describe the motor impairment/ competence of one child (case study from a larger study investigating the long term prognosis for children who are "clumsy").

Sample characteristics: One girl aged 16 years. Identified by her teacher at the age of 5 years as having poor motor coordination. Verbal IQ was above average at 121 (from the WISC).

TEST DATA: At age 5 she scored below the 5th percentile for her age; at age 16 she obtained the lowest possible score.
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Herrgard, E., Luoma, L., Tuppurainen, K., Karjalainen, S. & Martikainen, A. (1993).

Neurodevelopmental profile at five years of children born at ≤32 weeks gestation.

Developmental Medicine and Child Neurology, 35, 1083-1096.

Summary
Sixty children born preterm (gestational age ≤32 weeks) and 60 control children matched by sex, and socio-economic and educational status of the parents were followed prospectively to the age of five years. Neurodevelopmental problems were surveyed by a detailed neurological and neuropsychological test battery, and by ophthalmological and hearing examinations. All except one of the preterm children with major disability had motor, visual-spatial and visual problems. The most frequent neurodevelopmental abnormalities encountered among preterm children without major disability were motor problems – emerging as gross and fine motor and/or visual-motor difficulties – and visual-spatial problems. Language difficulties were not associated with hearing problems. Among those without major disability, visual-spatial difficulties and opthalmological problems seldom emerged simultaneously.
Edition employed and profession of tester: Parts of the TOMI (1984). Three modified items were used – Flower Trail (errors and line quality recorded), Post Coins (completion time recorded) and Thread Beads (completion time and quality of performance recorded). These items were employed as part of a battery of 'visuo-motor tasks' (Flower Trail) and 'fine motor tasks' (Post Coins and Thread Beads). Administered by a paediatric neurologist. Performance on tasks was scored 0 for abnormal, 1 for borderline and 2 for optimal.
Reason for using the test: To measure and compare motor impairment/ competence of children born prematurely and controls.
Sample characteristics and control procedures: Finnish children aged 5 years. Index group (n=60, 29 boys, 31 girls): born preterm (gestational age of 32 weeks or less), 1984-1986 in Kuopio University Hospital, Finland. Mean IQ = 110 (range: 20-142) (WPSSI). Control group (n=60): born full term and matched for gender, educational level and socio-economic status of parents with index group. Mean IQ = 123 (range: 88-144).
TEST DATA: No details provided.
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Johnson, A., Townshend, P., Yudkin, P., Bull, D. & Wilkinson, A.R. (1993).

Functional abilities at age 4 years of children born before 29 weeks of gestation.

British Medical Journal, 306, 1715-1718.

Summary
The aim of this study was to assess the rate of impairment and disability among babies born very preterm and to investigate the association between such impairment and gestational age at birth. The cohort consisted of a geographically defined population of babies born alive before 29 weeks of gestation to mothers resident in the Oxford Regional Health Authority during 1984-6. Survival rates and rates of impairment and disability among survivors at the age of 4 years were measured. Of the 342 babies, half (170) survived to be discharged home. Of the 164 survivors to age 4 years, 153 (93%) were assessed. A total of 35 (23%; 95% confidence interval 16% to 30%) were severely disabled and only 54 (35%; 28% to 43%) were unimpaired. The risk of impairment and disability increased with decreasing gestational age at birth ($p<0.003$). It is concluded that with the increasing survival rate among babies born before 29 weeks of

gestation, we need urgently to establish reliable ways of monitoring the proportion of survivors who have a disability.
Edition employed: Movement ABC (1992).
Reason for using the test: To measure motor impairment/competence in children aged 4 years, born before 29 weeks of gestation.
Sample characteristics: 153 children born before 29 weeks of gestation to mothers resident in the Oxford region, U.K. during 1984-6.
TEST DATA: Test results alone were not reported. Childrens' performance on a range of tests was used to allocate them to one of 5 categories based on the estimated level of impairment and functional disability.
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Jongmans, M., Demetre, J.D., Dubowitz, L. & Henderson, S.E. (1996).

How local is the impact of a specific learning difficulty on premature children's evaluation of their own competence?

Journal of Child Psychology and Psychiatry, 37(5), 565-568.

Summary
The aim of this study was to determine whether children's perceptions of their own competence levels reflected their actual strengths and weaknesses (Specificity Hypothesis) or transcended these (General Hypothesis). Harter and Pike's measure of self-perception was administered to 163 prematurely born 6-year-olds with or without motor co-ordination and/or reading problems. Associations between children's self-perceptions and their scores on standardized tests of motor co-ordination and reading were assessed in three distinct ways. These analyses produced converging results: self-perceptions of physical competence were associated specifically with performance on the Movement ABC Test, and self-perceptions of cognitive competence were associated specifically with performance on the BAS Word Reading Scale. These results support the Specificity Hypothesis.
Edition employed and profession of tester: Movement ABC (1992). Administered by a research psychologist.
Reason for using the test: To obtain an objective measure of motor impairment/competence in children born prematurely.
Sample characteristics: 163 children with mean age 76 months (SD: 3.2), born prematurely (<35 weeks gestation) between 1984-1986. All had received neonatal intensive care at the Hammersmith Hospital in London, U.K. All attended mainstream schools. The group included nine ambulatory children with mild cerebral palsy (more severely impaired, wheelchair bound children were omitted from the study). The children were divided into four groups according to whether they had co-ordination problems (Movement ABC score below 15th percentile, score of 6 or more) and/or reading problems (Word Reading Scale from BAS below 15th percentile, T-score 40 or less). According to these criteria 66 children had no problems with reading or co-ordination (group 1), 21 children had reading problems only (group 2), 59 had co-ordination problems only (group 3) and 17 had both reading and co-ordination problems (group 4).
TEST DATA: Group 1 Mean = 2.02 (SD: 1.64), group 2 Mean = 2.62 (SD: 1.72), group 3 Mean = 11.58 (SD: 5.59), group 4 Mean = 15.94 (SD: 6.81). Analyses of variance showed that perceptuo-motor status (derived from the 15th percentile point of the Movement ABC) was significantly associated with both birth weight ($F(1,159)=5.95$, $p<.05$) and gestational age ($F(1, 159) = 9.34$, $p<.01$). Chi square tests showed that there was a tendency for the incidence of co-ordination difficulties to be higher in boys than in girls ($X^2 = 3.20$, $df = 1$, $p<.10$). Using multiple regression analysis, motor co-ordination was the only significant predictor of the physical competence scores on the Pictorial Scale of Perceived Competence and Social Acceptance for Young Children (Harter & Pike, 1983; $B = -.27$, $p<.01$). The analyses showed a trend for motor coordination difficulty to be associated with higher peer acceptance scores ($B = 0.22$, $p<.05$). In a multidimensional frequency analysis there was a significant association between motor competence scores and physical self-perception scores ($X^2 = 6.25$, $df = 1$, $p<.05$).

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Jongmans, M., Henderson, S.E., de Vries, L. & Dubowitz, L. (1993).

Duration of periventricular densities in preterm infants and neurological outcome at 6 years of age.

Archives of Disease in Childhood, 69, 9-13.

Summary
Parenchymal echogenicities that break down into extensive cystic lesions are generally followed by severe motor deficit. However, the effect of echodensities in the periventricula white matter, so called 'flares', on later development is less well documented. The aim of the present study was to investigate the impact of neonatal flares in preterm infants on neurological status and motor competence at 6 years of age and to see to what extent outcome was related to duration of flares. Forty four children with flares, subdivided into three groups according to the duration of flares, and 62 children with normal scans were assessed on Touwen's neurological examination, the Movement ABC, and the British Ability Scales. No differences in cognitive abilities were found between the groups. The results of the motor assessments showed that performance decreased significantly with increasing duration of flares. In addition, there was a suggestion that this trend was stronger in measures assessing lower limb function than those of upper limb. Teachers were also able to identify differences between the groups of children on the basis of their motor performance in school.
Edition employed and profession of tester: Movement ABC (1992). Both the formal test and the checklist were employed.
Reason for using the test: To assess motor impairment/competence of children born prematurely and to examine performance in relation to the duration of 'flares'.
Sample characteristics: 106 children aged 6 years born in London, England. All born preterm (gestational age ≤34 weeks) with no congenital abnormalities. Sub-divided according to the presence and duration of flares: Group 1 (n=62): normal scans, Group 2 (n=13): flares <7 days, Group 3 (n=18): flares 7-14 days, Group 4 (n=13): flares > 14 days. There were no significant differences between the groups on age at follow-up or on cognitive ability (using the British Ability Scales, Elliott, Murray & Pearson, 1983)
TEST DATA: Median total score: group 1 = 4 (0-23.5), group 2 = 6.5 (1-20.5), group 3 = 7.5 (0-25), group 4 = 9.5 (0-27.5). Trend analysis (Jonckheere test for ordered alternatives) showed increasingly poor *Movement ABC* scores were associated with increasing duration of flares (J=2.97, $p<0.01$). Results for each item are also provided. Statistically significant trends were found for all of the items designed to assess 'static and dynamic balance' as well as for two of the 'manual dexterity' items. Mean checklist item score: group 1 = 0.48 (0.00-1.52), group 2 = 0.42 (0.09-1.38), group 3 = 0.59 (0.11-1.50 0), group 4 = 1.10 (0.70-1.49). A significant overall trend of increasing mean item score was found across the four groups (J=2.39, $p<0.01$). Regression analysis showed the effect of flare duration on formal test scores was significant (t ratio 2.49, $p<0.014$). On the checklist, the coefficient of flares was 1.62 ($p=0.110$). For test and checklist scores, gestational age accounted for the greater proportion of the variance (t=3.07 and 2.69 respectively, both $p<0.01$)
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Jongmans, M., Mercuri, E., Henderson, S., de Vries, L., Sonksen, P. & Dubowitz, L. (1996)

Visual function of prematurely born children with and without perceptual-motor difficulties.

Early Human Development, 45, 73-82.

Summary
The relationship between visual and perceptual-motor abilities at 6 years of age was investigated in a cohort of 141 prematurely born children without cerebral palsy. Visual acuity was assessed using the Sonksen-Silver Acuity System and stereopsis with the Titmus Stereo test. Perceptual motor abilities were evaluated using the Movement Assessment Battery for Children and the Developmental Test of Visual-Motor Integration. The results showed a higher incidence of abnormalities both of linear acuity and stereopsis in the study group when compared to a group of reference children. Whereas abnormalities of linear acuity were not associated with perceptual-motor difficulties, abnormal stereopsis was significantly associated with poor performance on both perceptual-motor tests. The results suggest that infants born preterm even in the absence of other major neurological signs, are at risk for abnormal visual function and perceptual-motor difficulties. As such problems could interfere with everyday life and school performance, a longitudinal assessment of both areas of competence is recommended so that diagnosis and possible intervention can take place as early as possible.
Edition employed: Movement ABC (1992).
Reason for using the test: To obtain local norms for the test and to examine the relationship between motor impairment/competence and visual function in children born prematurely.
Sample characteristics and control procedures: Index group (n=141): aged six years**,** born at, or admitted soon after birth to, the Neonatal intensive care unit at the Hammersmith Hospital in London. Gestational age ≤34 weeks, no congenital abnormalities. All attended mainstream schools with IQ 81-134 on the short form of the British Ability Scales. Reference group (n=88): used to obtain local norms for the *Movement ABC* test. Matched on age, gender and Social Economic Status with the index group.
TEST DATA: Index group mean total score = 6.2 (SD: 5.66, Range: 0-23.5). 64 (45%) had scores above the 15th centile (5.5). Reference group mean total score = 3.36 (SD: 4.70, Range: 0-26). The difference between the two groups was statistically significant ($F(1,228)=16.13$, $p<.001$). Performance on the *Movement ABC* was significantly related with stereopsis ($\chi^2=7.58$, df=1, $p<.01$)
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Kooistra, L., Laane, C., Vulsma, T., Schellekens, J.M.H., Van der Meere, J.J. & Kalverboer, A.F. (1994).

Motor and cognitive development in children with congenital hypothyroidism: A long-term evaluation of the effects of neonatal treatment.

Journal of Pediatrics, 124(6), 903-909.

Summary
Although neonatal thyroid screening programs have been of value in preventing cerebral damage, there is still debate about whether patients with congenital hypothyroidism (CH) achieve normal motor and cognitive skills. This study examines the motor and cognitive skills of 72 children with early-treated congenital hypothyroidism and 35 control subjects at the ages of 7½ and 9½ years. The relative influence of cause, blood thyroxine concentration at the time of screening, and age at the start of thyroxine replacement therapy on motor and cognitive development was investigated. Despite having received treatment at a mean age of 23 days, children with low neonatal thyroxine (T4) concentrations (<50nm0l/L) at screening, particularly children with thyroid agenesis, had significant motor problems and borderline intelligence scores as late as 9½ years of age. Balance and ball skills seemed to decline between 7½ and 9½ years of age, whereas language and memory functions seemed to be maintained. Significant correlations between the start of therapy and both motor scores and performance IQ scores at the age of 7½ years in children with severe hypothyroidism show the importance of early treatment for these patients.
Edition employed: TOMI (1984).
Reason for using the test: To provide an objective measure of motor impairment/competence of children with CH.
Sample characteristics and control procedures: From the total population of Dutch children born with CH in 1981-1982 (n=133) 72 children participated in the first phase of the study (14 boys, 58 girls). Their

mean age was 7.9 years, range: 7.0-8.5. They were classified in two ways. Firstly, by diagnostic category: Thyroid agenesis (n=24), Thyroid dysgenesis (n=30), Thyroid dyshormonogenesis (n=9), Transient thyroid inhibition (n=9). Secondly, according to initial T4 levels: Low T4 group: n=48, mean T4 25 nmol/L, Intermediate T4 group: n=23, mean T4 86 nmol/L. Control group (n=38): matched for age, sex and social status with the index children. Two years later, in the second phase of the study, 65 of the original children with CH and 34 of the original controls were seen again.
TEST DATA: The scores of the index group were significantly worse than controls for the total *TOMI* and for the manual dexterity and balance sub-tests. From 7½ to 9½ years of age the relative differences on the total *TOMI* and balance scales remained unchanged. Differences on the fine motor scale were not significant at 9½ years.
Diagnosis: Thyroid dyshormonogenesis and iodine excess groups – at both times of testing did not differ significantly from controls. Thyroid agenesis group – On first testing, total *TOMI*, manual dexterity and ball skills scores were significantly worse than controls. On second testing there was also a highly significant difference for balance. Thyroid dysgenesis group – On first testing, total *TOMI* and manual dexterity scores were significantly worse than controls. At second testing, there were no significant differences.
Initial T4 levels: Low T4 – At both ages had significantly worse scores than controls on total and all sub scores of *TOMI*. Intermediate T4 – Significantly worse than controls at age 7 on fine sub-scale. At 9 years improved on every *TOMI* scale.

Partial correlations (adjusted for effects of time of start of therapy) between neonatal T4 level and individual *TOMI* scores were significant at age 7 (r=.39, p<.01) and age 9 (r=.44, p<.01). At age 7 there were significant correlations between time of therapy commencement and individual *TOMI* scores (r=,45, p=.03) in the thyroid agenesis group. There were comparable correlations in the low T4 group (r=.32, p=.04). At age 9 these correlations were not significant. Performance changes from 7 to 9 years within the different etiologic groups never reached the 0.01 significance level.
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Psychomotor development in congenital hypothyroidism.

In M.L. Simner, W. Hulstijn & P.L. Girouard (Eds) *Contemporary issues in the forensic, developmental and neurological aspects of handwriting*. Vol. 1. Toronto: Association of Forensic Document Examiners, pp65-83.

Summary
This paper describes the motor development of children who were screened and treated for Congenital Hypothyroidism (CH) shortly after birth. In the first phase of the investigation data was obtained which confirmed the prevailing view that, despite early treatment, children who exhibited low levels of blood thyroxine at screening continued to experience motor as well as cognitive problems as late as seven to eight years of age. In the second phase of the investigation an experimental approach was used to examine the fine motor (handwriting) performance of these children in terms of motor control and motor programming. The outcome of this work showed that, in relation to normal control children, children with low levels of blood thyroxine (T4) at the moment of screening typically display longer reaction times, greater variability in trace length, higher levels of fluency, shorter movement times and shorter pauses between strokes. Several alternative explanations that may help to account for these findings are discussed.
Edition employed: TOMI (1984).
Reason for using the test: To measure the level of motor impairment/competence in children with CH.
Sample characteristics and control procedures: *Diagnostic Phase.* Index group (n=71) with primary CH, consisting of : Low T4 group (< 50 nmol/l of blood thyroxine) – 48 children (6 boys, 42 girls) whose treatment began, on average, 23 days after birth, Medium T4 group (>or equal to 50 nmol/l of blood thyroxine) – 23 children (7 boys, 16 girls) whose

treatment began on average 67 days after birth. Control group (n=35, 11 boys, 24 girls): Mean age in all three groups was 7 years, 10 months. *Experimental Phase.* Index group (n=68) with primary CH. Consisting of : Low T4 group (n=42) – (5 boys, 37 girls) whose treatment began, on average, 22 days after birth, Medium T4 group (n=20, 5 boys, 15 girls) whose treatment began on average 68 days after birth. Control group (n=31, 10 boys, 21 girls). Mean age in all three groups was 7 years, 11 months. Using the WISC-R the Low T4 group had significantly lower Full, Verbal and Performance IQ scores than the control group. The Medium T4 group had significantly lower Full and Performance IQ scores than controls. There were no significant differences in IQ scores between the Low and Medium T4 groups.
TEST DATA: *Diagnostic Phase* Total and sub-test scores were significantly worse in the Low T4 group than the control group. The Low T4 group also performed more poorly than the Medium T4 group on the manual dexterity sub-test. *Experimental Phase* Mean total scores for groups: Low T4 = 4.1 (SD = 2.3), Medium T4 = 2.8 (SD = 1.19) Control = 2.0 (SD = 1.5).
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Levene, M., Dowling, S., Graham, M., Fogelman, K., Galton, M. & Phillips, M. (1992).

Impaired motor function (clumsiness) in 5 year old children: correlation with neonatal ultrasound scans.

Archives of Disease in Childhood, 67, 687-690.

Summary
All 155 surviving children from a cohort of 200 very low birthweight infants originally studied in 1984-5 were traced. These infants had careful sequential ultrasound examinations in the neonatal period. The children were examined again at entry to school at 5 years of age. The TOMI and the vocabulary subscale of the Wechsler preschool and primary scale of intelligence (WPPSI) were administered to 152 of the index cohort and 144 control children of the same age in the same class at school. Twelve of the cohort had cerebral palsy, but eight of these were in mainstream schools. The index group scored significantly higher on both the TOMI and the WPPSI subscale compared with the controls. The index cases were subdivided on the basis of their neonatal ultrasound scans into four groups: group 1, consistently normal; group 2, 'prolonged flare'; group 3, germinal matrix haemorrhage-intraventricular haemorrhage (GMH-IVH), without parenchymal haemorrhage, but no evidence of prolonged flare; and group 4, both GMH-IVH and prolonged flare. The group of index children with consistently normal ultrasound scans had a higher TOMI and lower WPPSI compared with their controls. There was a statistically significant increase in the TOMI manual dexterity subscore in group 4 infants compared with group 1, but no differences between the other groups. Regression analysis suggests that neither prolonged flare nor GMH-IVH has an important individual contribution to the variation, but that low birth weight does have a significant relationship with motor impairment. It appears that relatively minor ultrasound appearances such as prolonged flare and GMH-IVH are associated with motor impairment (clumsiness) at 5 years, but this has a small effect compared with low birth weight.
Edition employed: TOMI (1984).
Reason for using the test: To assess and compare motor impairment/competence in children born of very low birthweight (VLBW) and controls.
Sample characteristics and control procedures: Children aged 5 years. Index group (n=152): born 1984-85 of VLBW (<1501g) and admitted to the Leicester Royal Infirmary or the Nottingham City Hospital. Regularly studied with real time ultrasound in the neonatal period. Control group (n=144): selected from the same school and class as the index children and matched pairwise on the basis of age, gender and ethnic background. The index children were subdivided into four groups. Group 1 had consistently normal ultrasound scans (n=64), group 2 had prolonged flare as the only ultrasound abnormality (n=13), group 3 had germinal matrix haemorrhage-intraventricular haemorrhage (GMH-IVH) as the only ultrasound abnormality and no parenchymal involvement (n=54) and group 4 infants had both prolonged flare and GMH-IVH without parenchymal involvement (n=9). The index group obtained significantly lower scores on the vocabulary scale of the WPPSI (Index mean = 19.1 (SD: 6.41), Control mean = 21.6 (SD: 6.46), p=.0007) but differences between the four index groups were not statistically significant.

TEST DATA: Index group median total score = 3.25 (Range: 0-16), Control group median total score = 1.00 (Range: 0-8). Statistical analysis of 144 pairs revealed the difference between the groups to be statistically significant for the total score and each of the subscores (p<.001). Total mean scores were: group 1 = 2.25 (Range: 0-16), group 2 = 4.5 (Range: 0.5-9.5), group 3 = 3.0 (Range: 0-13), group 4 = 5.5 (Range: 1-13). The differences between the groups were not statistically significant. The subscore for items requiring manual dexterity were: group 1 = 0.5 (Range: 0-6), group 2 = 0.5 (Range: 0-5.5), group 3 = 1.0 (Range: 0-5), group 4 = 1.5 (Range: 1-4). The difference between scores for groups 1 and 4 were statistically significant (P=.033). Regression analysis, using the square root of total TOMI score as the dependent variable, showed that birth weight accounted for the greatest proportion of the variation.

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Clumsiness in children – do they grow out of it? A 10-year follow-up study.

Developmental Medicine and Child Neurology, 33, 55-68.

Summary
This paper reports the findings from a follow-up study of 17 children, identified by their teachers as having poor motor co-ordination at age six. Now at 16, these children and their matched controls completed a battery of assessments. The results suggest that the majority of children still have difficulties with motor co-ordination, have poor self-concept and are experiencing problems of various kinds in school. However, there are individual differences in the extent to which the children have learned to cope with their continuing difficulties over the years.

Edition employed and profession of tester: TOMI (1984).
Reason for using the test: To assess and compare motor impairment/competence in children earlier identified as having motor co-ordination difficulties and controls.
Sample characteristics and control procedures: Children aged 15-17 years. At age six were all in mainstream school. Index group (n=17, 14 boys, 3 girls): identified at age six as having co-ordination problems. Control group (n=17): individually matched with index children at age six on age and gender. Each pair was in the same class at school at age six. Using the WISC-R (Wechsler, 1974) Verbal IQ was found to be significantly lower in the index group (88.00 vs 99.73 p<.05) but the difference between the groups on Performance IQ was not statistically significant (98.13 vs 108.73).
TEST DATA: When 11-12 year old norms were applied to the individual item scores, the 15-17 year old index group achieved total *TOMI* scores of mean = 3.16 (SD: 2.43), Control group mean = 0.13 (SD: 0.35). The difference between the means was statistically significant (p<.001). For all of the test items, the difference between the groups was consistently in favour of the control group. For five of the eight individual test items this difference was statistically significant (min. p<.05). In the opinion of the examiners, quantitative measures taken in the formal test tended to under-estimate the qualitative differences between the groups.

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Marlow, N., Ellis, A.M., Roberts, B.L. & Cooke, R.W.I. (1990).

Five year outcome of preterm sextuplets related to size at birth.

Archives of Disease in Childhood, 65, 451-452.

Summary

Preterm sextuplets were studied to examine whether growth retardation affects long term outcome. All were growing normally at 5 years. Intelligence quotients (IQ) ranged from 105-116 and motor impairment scores from 1.0-7.0. No neurological or behavioural abnormalities were found. The largest sextuplet has maintained her position for growth and IQ. No relation between test scores and birth weight or perinatal variables was found in the remaining siblings.
Edition employed: TOMI (1984). Administered by a Paediatrician.
Reason for using the test: To assess and compare motor impairment/ competence in sextuplets.
Sample characteristics and control procedures: Index group (n=6): sextuplets aged five years. Born at 31 weeks gestation. General IQ range = 105-116, Visual IQ range = 100-117, Verbal IQ range = 105-116 on the British Ability Scales. Control group (n=53): aged 6 years, described in Marlow, Roberts and Cooke (1989).
TEST DATA: Index group range = 1.0-7.0, Control group median score = 3.0. No perinatal factor was able to predict the order of the *TOMI* scores at 5 years.
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Marlow, N., Roberts, B.L. & Cooke, R.W.I. (1989).

Motor skills in extremely low birthweight children at the age of 6 years.

Archives of Disease in Childhood, 64, 839-847.

Summary
Fifty three children aged 6 years old who had weighed less than 1251g at birth without cerebral palsy and receiving mainstream education, were entered into a controlled study of motor skills. The index and control children were matched by age, sex, and school. The index group were considered by their teachers to have similar academic performance to their controls, although two index cases were receiving remedial teaching. On the test of motor impairment extremely low birthweight children had significantly more motor difficulties than controls. In addition, the index group had more minor neurological signs, lower intelligence quotients, and more adverse behavioural traits. The higher motor impairment scores amoung index children were independent of differences in intelligence quotient between the two groups. There was no association between impairment score and the presence or degree of periventricular haemorrhage or periventricular leucomalacia on neonatal cerebral ultrasound. Children with Apgar scores at five minutes of less than 7 had significantly higher impairment scores compared with those whose scores were 7 or more. Three perinatal factors (Apgar score at five minutes, neonatal septicaemia, and abnormal movements) explained 32% of the variance in impairment score at the age of 6 years. In children who do not have cerebral palsy perinatal factors may still be important in the development of motor skills. The presence of subtle neuromotor impairments at 6 years of age has implications for schooling that need further evaluation.
Edition employed: TOMI (1984).
Reason for using the test: To assess and compare motor impairment/competence in children born of extremely low birthweight (ELBW) and controls.
Sample characteristics and control procedures: Children aged 6 years attending normal schools. Index group (n=53): children born of ELBW (<1251 g) in 1980-81 at the Liverpool Maternity Hospital. Control group (n=53): matched pairwise with index children. Selected by taking a classmate of the same sex and with the nearest birthday. Using the WPPSI (Wechsler, 1967), median IQ was significantly lower in the index group (109 vs 117, p=.001), although all scored above 84. The Verbal and Performance quotient were also significantly lower in the index group (p=.05 and p<.001 respectively).
TEST DATA: Index group median total score = 6.0 (Range: 0-15), Control group median total score = 3.0 (Range: 0-13). On seven of the eight individual test items the index group performed significantly less well than the controls. Despite a large overlap of results only 10 index children had equal or lower scores than their matched control. Total *TOMI* scores correlated significantly with the presence of neurological signs (Touwen, 1979; all signs: r^2 =.235, p<.0001; pronounced signs: r^2=.242, p<.0001) and with IQ (p=.0001). Of all the outcome variables the total number of minor neurological signs present correlated best with the total *TOMI* score (r^2: 0.24). No association between periventricular haemorrhage or parenchymal lesions and

total *TOMI* scores was observed. Analysis of single factors showed that only an Apgar score at five minutes of less than 7 was significantly associated with total *TOMI* scores at the age of 6 years (Mann-Whitney U test: p=.014). Forward stepwise multiple regression analysis showed that three perinatal variables were associated with *TOMI* scores. A decreasing Apgar score at five minutes, proven neonatal septicaemia, and the presence of abnormal movements were associated with higher (worse) scores (r: 0.566). Together these factors explained 32% of the variance in *TOMI* scores.

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This is the first in a series of follow-up studies of the same cohort of children. Subsequent studies are reported in: Marlow, N., Roberts, L. & Cooke, R. (1993). Outcome at 8 years for children with birth weights of 1250 g or less. *Archives of Disease in Childhood,* 68, 286-290.

Powls, A., Botting, N., Cooke, R.W.I. & Marlow, N. (1995). Motor impairment in children 12 to 13 years old with a birthweight of less than 1250 g. *Archives of Disease in Childhood,* 72, F62-F66.

Marlow, N., Roberts, L. & Cooke, R. (1993).

Outcome at 8 years for children with birth weights of 1250 g or less.

Archives of Disease in Childhood, 68, 286-290.

Summary
The educational, motor, and behavioural performance of a hospital based cohort of 51 children aged 8 years with birth weights of 1250 g or less is reported, as part of a longitudinal study. Compared with age, race and sex matched classmates, who were examined at school at the same visit, the very low birthweight (VLBW) group performed less well on the basic mathematics test A, the Schonell spelling test and the test of motor impairment. Reading performance was also poorer in this group. Twenty three (45%) VLBW children were having difficulty with one or more school subjects compared with 11 (19%) controls; and 15 (26%) had difficulties in two or more areas, compared with three (5%) controls. Parents of VLBW children reported a similar frequency of behavioural problems to controls but teachers identified characteristics typical of emotional disorders and overactivity more frequently among the VLBW group. Motor testing at 6 years of age was the best predictor of school problems at 8 years, correctly identifying 15/16 children with multiple problems with a low (33%) positive predictive value but a high (98%) negative predictive value. Children with birth weights of 1250 g or less and no major impairment have a high frequency of learning difficulties that become more apparent with advancing age. Such problems may be predicted at an earlier age by detailed motor testing.

Edition employed: TOMI (1984).

Reason for using the test: To assess and compare motor impairment/competence in children born of very low birthweight (VLBW) and controls.

Sample characteristics and control procedures: Children aged 8 years. Previously studied at 6 years. Index group (n=51): born in 1980-81 of very low birthweight (VLBW). At six years of age they were free of cerebral palsy or sensory impairment. Median age = 96 months (Range: 85-117). Control group (n=59): matched with index children on age and gender. 44 were the same controls as used in the previous examination (although 8 were now at a different school), 15 were new controls. Median age = 97 months (Range: 81-106).

TEST DATA: Index group median total score = 3.5 (interquartile range: 3-5), Control group median total score = 2.0 (interquartile range: 1-4). There was a fall in total scores between six and eight years (paired Wilcoxon: Z=-4.566, p<.001) which was more marked in the VLBW group (median change -2.5, interquartile range –3.5 to -0.5) compared with the controls (-0.5, -1.5 to 1.0, p= .008; paired Wilcoxon test). The difference between the groups was statistically significant for seven of the eight individual test items. Discriminant function analysis, using poor performance in two or three subjects as the dependent variable, identified that the total *TOMI* score at 6 years was the best discriminant of all the six year measures. A total score of five or more at 6 years correctly identified 15 (94%) children with school problems in two or more areas, with a low positive predictive value of 33%, but a high

negative predictive value of 98%.
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This is one in a series of follow-up studies of the same cohort of children. The other studies are reported in:

Marlow, N., Roberts, B.L. & Cooke, R.W.I. (1989). Motor skills in extremely low birthweight children at the age of 6 years. *Archives of Disease in Childhood,* 64, 839-847.

Powls, A., Botting, N., Cooke, R.W.I. & Marlow, N. (1995). Motor impairment in children 12 to 13 years old with a birthweight of less than 1250 g. *Archives of Disease in Childhood,* 72, F62-F66.

Mercuri, E., Jongmans, M., Henderson, S., Pennock, J., Chung, Y.L., de Vries, L. & Dubowitz, L. (1996).

Evaluation of the corpus callosum in clumsy children born prematurely: A functional and morphological study.

Neuropediatrics, 27, 317-322.

Summary
The aim of this study was to evaluate the incidence of functional and neuroradiological abnormalities of the corpus callosum in a group of 21 prematurely born children (GA <34 weeks) who were found to be "clumsy" on the Movement ABC at 6 years of age. All children underwent functional and morphological assessment of the corpus callosum. The functional assessment included tests of somesthesis, diadochokinesis and repetitive finger tapping. The morphology of the corpus callosum was evaluated on midsagittal MRI. Thirteen of the 21 clumsy children showed morphological abnormalities which were significantly associated with functional abnormalities. Morphological changes of the corpus callosum were also significantly associated with lesions on both neonatal ultrasound and late MRI. The results support the view that morphological abnormalities of the corpus callosum are frequent in children born prematurely. The association between these abnormalities and lesions on Ultrasound or MRI suggests that they are likely to be secondary to pre- or perinatal lesions.
Edition employed: Movement ABC (1992).
Reason for using the test: To obtain an objective measure of motor impairment/ competence in children born prematurely.
Sample characteristics and control procedures: Twenty one children (8 girls, 13 boys) with mean age 8 years, 6 months (range 6 years to 10 years, 5 months), all born at, or admitted soon after birth to the Hammersmith Hospital after January 1984. Inclusion criteria for the study were 1) gestational age of ≤34 weeks; 2) serial neonatal ultrasound scans, 3) a diagnosis of perceptuo-motor difficulties at the age of 6 years based on performance of the *Movement ABC* and 4) no mental retardation. Twenty four school children, matched for age, gender and race were also assessed.
TEST DATA: No test data is provided.
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Mutch, L., Leyland, A. & McGee, A. (1993).

Patterns of neuropsychological function in a low-birthweight population.

Developmental Medicine and Child Neurology, 35, 943-956.

Summary

An investigative analysis was carried out of the neuromotor and cognitive findings in a population-based study of low-birthweight infants (<1750g) at 4½ years of age to improve the understanding of the neuropathological basis of their deficits. Cluster analysis indentified groups of children whose performance in the cognitive subscales of the British Ability Scales followed similar patterns, and also differentiated between children in neuromotor competence. Cluster membership correlated highly with language attainment, ability to copy shapes, behaviour as reported by parents and parents' and examiners' perception of attention span. Children in poorer-performing clusters were more likely to be born to mothers who had had a previous perinatal death and were also more likely to have experienced septicaemia during the neonatal period. These findings are discussed in the light of evidence from the neuropathological and physiological literature.
Edition employed: Movement ABC (1992).
Reason for using the test: To examine motor impairment/competence in a total population-based cohort of low-birthweight children.
Sample characteristics: 611 4½ year old children born of low birthweight (<1750g) in Scotland in 1984. Mean IQ score = 92.9 using four subscales of the British Ability Scales (BAS).
TEST DATA: 26% performed below 15th centile on overall score. The overall rate of motor impairment shows a statistically significant gradient with birthweight. This gradient was found for all items except catching, rolling ball and drawing.
Correspondence to:
Lesley Mutch
c/o National Perinatal Epidemiological Unit, Radcliffe Infirmary, Oxford, OX2 6HE, U.K.

North, K., Joy, P., Yuille, D., Cocks, N., Mobbs, E., Hutchins, P., McHugh, K. & de Silva, M. (1994).

Specific learning disability in children with neurofibromatosis type 1: Significance of MRI abnormalities.

Neurology, 44, 878-883.

Summary
To determine whether previously reported areas of increased T2 signal intensity on MRI examination in children with neurofibromatosis type 1 (NF 1) are associated with deficits in development and learning common in this population, 51 children with NF 1 (aged 8 to 16 years) were evaluated. Forty children completed the full assessment protocol (MRI, medical, psychometric, speech therapy and occupational therapy assessments). The mean Full Scale IQ scores for the entire study population showed a left shift compared with the normal population, and the distribution of IQ scores was bimodal, suggesting that there are two populations of patients with NF 1 – those with and those without a variable degree of cognitive impairment. There was no association between lower IQ scores and any clinical variable. Areas of increased T2 signal intensity unidentified bright objects (UBO+) were present in 62.5% of the study population, and their presence was not related to clinical severity, sex, age, socioeconomic status, macrocephaly or family history of NF 1. However, compared with children without areas of increased T2 signal intensity (UBO-), the UBO+ group had significantly lower mean values for IQ and language scores and significantly impaired visuomotor integration and coordination. Children with areas of increased T2 signal intensity were at a much higher risk for impaired academic achievement. Children without increased T2 signal on MRI (UBO-) did not significantly differ from the general population in any measure of ability or performance. Areas of increased T2 signal on MRI represent dysplastic glial proliferation and aberrant myelination in the developing brain and are associated with deficits in higher cognitive function. The presence of these abnormal signals on MRI divides the NF 1 population into two distinct groups anatomically and developmentally (UBO+ and UBO-). These two groups should be considered separately in the assessment and management of learning disability in children with NF 1.
Edition employed: TOMI (1984).
Reason for using the test: To assess and compare motor impairment/competence in children exhibiting different types of Neurofibromatosis type 1 (NF 1): those showing abnormal signals on Magnetic Resonance Imaging or MRI (areas of increased T2 signal intensity – called unidentified bright objects (UBO)) and children showing no

abnormalities on MRI.
Sample characteristics: Children in Australia aged 8-16 years (n=40). All had NF 1 and had been assessed in the Neurofibromatosis Clinic, The Children's Hospital, Sydney, 1991-1992. None had significant visual or hearing impairments. UBO+ group(n=25): Showed areas of increased T2 signal on MRI. UBO- group (n=15): Showed no abnormal signal on MRI. On the Wechsler Intelligence Scale for Children – Revised (WISC-R; Wechsler, 1984), the UBO+ group had significantly lower Verbal, Performance and Full IQ scores (Range: 74-131) compared with the UBO-group.
TEST DATA: For the whole group (n=40): 9 children were rated at an average level of ability, 11 had mild, 7 had moderate and 13 had definite problems with coordination. The presence of definite motor impairment was significantly associated with the presence of increased T2 signal on MRI (p=0.03 using Mann-Whitney).
Correspondence to:
Kathryn North
Genetics Division, Fegan10, Children's Hospital, 300 Longwood Avenue, Boston, MA 02115.

Pharoah, P.O.D., Stevenson, C.J., Cooke, R.W.I. & Stevenson, R.C. (1994).

Clinical and subclinical deficits at 8 years in a geographically defined cohort of low birthweight infants.

Archives of Disease in Childhood, 70, 264-270.

Summary
The aim of this study was to determine the prevalence of subclinical deficits in cognitive and motor function in low birthweight infants (weighing ≤2000g at birth). 233 matched index case-control pairs attending normal primary schools and 46 unmatched children attending special schools were included in the study. They were assessed using the Wechsler Intelligence Scale for Children (WISC), the Neale analysis of reading ability and the TOMI. Compared with controls, the index group had a lower WISC score (mean IQ difference 8.8; 95% confidence interval (CI) 6.8 to 10.7), a lower reading age (mean difference 6.5 months; 95% CI 4.0 to 9.0), and poorer motor performance as shown by the TOMI score (mean difference 1.4; 95% CI 1.1 to 1.8). Of the children attending special schools, 23/46 (50%) had a WISC score < or equal to 50. It is concluded that low birthweight children have significant subclinical deficits of cognitive and motor function and extra resources, especially in education, may be required to meet their needs.
Edition employed and profession of testers: TOMI (1984). Administered by trained researchers.
Reason for using the test: To assess and compare motor impairment/competence in a low birthweight and control group.
Sample characteristics and control procedures: 8 year old children. Index group (n=304): all born to mothers resident in Merseyside, U.K. in 1980-1. 220 of these had a birthweight ≤1500 g. 84 weighed 1501-2000g at birth. Of these 84, some were classified as disabled (n=22) or possibly disabled (n=2) at age 3 or had missed out on an assessment at the age of 3 years (n=14). The remaining 46 consisted of 10% of a random sample of children assessed as unimpaired at age 3. Control group (n=233): matched for every index child attending a normal mainstream school on gender, school and nearest birth date. 232 index-control matched pairs were sub-divided into birthweight groups ≤1000 g, 1001-1500 g, 1501-2000 g. For all three birthweight groups index children scored lower than controls on the WISC. Controls were not obtained for index children attending special schools.
TEST DATA: From 232 matched pairs 27 (11.6%) index children scored 6 or more, indicating definite motor impairment, 49 (21.1%) scored 4-5.5 indicating moderate motor impairment. Among the controls, 2 (0.9%) had a definite and 21 (9.1%) a moderate motor problem. The lowest birthweight group had higher scores and showed the greatest difference when compared to matched controls.
Correspondence to:
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Department of Public Health, PO Box 147, Liverpool, L69 3BX.

Powls, A., Botting, N., Cooke, R.W.I. & Marlow, N. (1995).

Motor impairment in children 12 to 13 years old with a birthweight of less than 1250 g.

Archives of Disease in Childhood, 72, F62-F66.

Summary
The aim of this study was to determine whether poor motor skills, previously identified in a cohort of very low birthweight (<1250 g) children, born in 1980-1, have persisted or improved. Previous assessments had shown significant improvement between the ages of 6 and 8 years. The original cohort were traced and were assessed using the Movement Assessment Battery for Children, an update of the Test Of Motor Impairment, used at 6 and 8 years. Where possible the classroom-matched controls from the original studies were assessed, otherwise new controls were selected. Teachers were also asked to identify those children whom they considered clumsy. Forty seven of the original cohort of 53 children, all but one still attending mainstream school and 40 original and 20 new classroom-matched controls were studied. Fifty one per cent of the cohort showed clinically important or borderline impairment. More of these children had significant impairment (16/47, 34%) than the controls (3/60, 5%). The improvement seen by 8 years of age was maintained but there was no further improvement. Girls had significantly higher overall impairment scores (median 16; interquartile range 10-21.5) than the boys (5.5 (1.5-12.5)) and on a wider variety of sub-tests (5/8) than the boys (3/8). It is concluded that many very low birthweight children have impaired motor skills which, despite early improvement, persist into adolescence. Interventional studies may help to see if these problems can be alleviated.
Edition employed: Movement ABC (1992).
Reason for using the test: To assess and compare motor impairment/ competence in children born of very low birthweight and controls.
Sample characteristics and matching procedures: Children aged 12-13 years, most of which had been previously studied at age 6 and 8 years. Index group (n=47): from the original cohort born in 1980-81 of very low birthweight (VLBW), all but one attended mainstream school. Control group (n=60): matched with index children for age and gender. 40 were the same controls as in the previous examination, 20 were new classroom-matched controls. There were no significant group differences for age, maternal or paternal occupational status, or for single parent families.
TEST DATA: Performance at 12-13 years. The index group had higher impairment scores than controls on all eight items of the test. This was significant in six (Mann-Whitney U) but not in the items 'throwing at a target' and 'jumping and 'clapping'. The most significant differences were seen in the tests of manual dexterity. Total scores for the index group: Median = 10.0, Interquartile Range = 3.5-16 and control group: Median = 2.5, Interquartile Range = 0.5-6. The scores were significantly higher in the index group (Mann-Whitney U, $p<.0001$). In the index group 24/47 (51%) scored between the 5th and 15th percentile (total score of 10-13), compared with 5/60 (8.5%) of controls. This difference is statistically significant ($\chi^2=24$, df=1, $p<.0001$). 16/47 (34%) scored below the 5th percentile (total score greater than 13) compared with 3/60 (5%) of controls. This difference is statistically significant ($\chi^2=15.2$, df=1, $p<.0001$). Total scores for index girls: Median = 16, Interquartile Range = 10-21.5 and boys: Median = 5.5, Interquartile Range = 1.5-12.5. The scores were significantly higher for the girls ($p<.008$). The girls also scored significantly worse than controls on a wider range of sub-tests (3 manual dexterity items and 2 balance items) than the boys (cutting, tracing and catching).
Comparison of performance at 6, 8 and 12 years. The three point scoring system of the *TOMI* (1984) was used to analyse longitudinal performance in the index children and those controls seen on more than one occasion. The index group scores had significantly improved from 6 years of age (median = 6) to 8 years of age (median = 3.5, $p<.0001$). This improvement was maintained but there was no further fall in their scores by the age of 12 to 13 years (median = 4.0, differences from 8 year score $p=0.54$). A similar picture was seen in the controls. The six year and eight year scores from the *TOMI* were predictive of the *Movement ABC* scores at 12-13 years, both showing significant correlations ($r=.54$ and $r=.52$ respectively, both $p<.001$). Some more detailed information on the development of individual children from age 6 to 12 years is provided in the paper. The correlation between motor scores with a range of perinatal variables were examined. Univariate analysis showed no significant associations. The results from a teachers questionnaire, in which they were required to say whether they considered the children to be clumsy using a simple yes/no scale, showed little correlation with the results of the test.
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Andrew Powls
Institute of Child Health, Liverpool University, Alder Hey Children's Hospital, Eaton Road, Liverpool, UK.

This is one in a series of follow-up studies of the same cohort of children. The other studies are reported in:

Marlow, N., Roberts, B.L. & Cooke, R.W.I. (1989). Motor skills in extremely low birthweight children at the age of 6 years. *Archives of Disease in Childhood, 64,* 839-847.
Marlow, N., Roberts, L. & Cooke, R. (1993). Outcome at 8 years for children with birth weights of 1250 g or less. *Archives of Disease in Childhood,* 68, 286-290.

Rantala, H., Uhari, M., Saukkonen, A. & Sorri, M. (1991).

Outcome after childhood encephalitis.

Developmental Medicine and Child Neurology, 33, 858-867.

Summary
The prognosis for 73 children treated for encephalitis between 1973 and 1983 was evaluated. 70 children participated in a follow-up examination 2.4 to 12.9 years after the acute phase of the disease. The 61 school-aged children had lower performance and full-scale IQs than their randomly selected, age- and sex-matched controls. Visual acuity was more often reduced, and they more often had focal slowing on EEG and electronystagmogram abnormalities. Clinically, these differences were not significant. Encephalitis with a poor prognosis occurred seldom, the incidence being 3.5 cases per one million children at risk annually. These results show that the prognosis for childhood encephalitis is much better than anticipated on the basis of experience mainly with herpes simplex virus encephalitis.
Edition employed: TOMI (1984).
Reason for using the test: To assess motor impairment/competence of children treated for encephalitis.
Sample characteristics and control procedures: Finnish children aged 2-25 years (test only employed with children aged 5-11 years). Index group (n=70. 37 girls, 33 boys): had been treated for encephalitis. Control group (n=70): matched on age and gender with the index group and chosen randomly from the population register. Scores from the WISC were all within the normal range.
TEST DATA: No statistically significant differences were found between the groups in manual dexterity, ball skills, dynamic or static balance tasks. In the 5-11 year age group a definite motor problem (total score of 6 or more) was found in 31% of index children (eight of 26) and 26% of control children (seven of 27).
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Matti Uhari
Associate Professor, Department. of Paediatrics, University of Oulu, SF-90220, Oulu 22, Finland.

Roth, S.C., Baudin, J., McCormick, D.C., Townsend, J., Stewart, A.L. & Reynolds, E.O.R. (1993).

Relation between ultrasound appearance of the brain of very preterm infants and neurodevelopmental impairment at eight years.

Developmental Medicine and Child Neurology, 35, 755-768.

Summary
The relation between the ultrasound appearance of the brain and neurodevelopmental outcome at eight years of age was investigated in 206 infants born between 1979 and 1982 at < 33 weeks gestation (600 to 2500g birthweights). Only 4 per cent of the 112 infants with normal scans at discharge from the neonatal unit developed major, disabling impairment. No significant adverse effect of uncomplicated periventricular haemorrhage was detected. The probability of a major impairment in infants with ventricular dilatation or hydrocephalus was 27 per cent, and 69 per cent in those with cerebral atrophy, 44 per cent of the children demonstrated significant differences in their cognitive processing skills, which appeared capable of affecting learning and may possibly have been caused by undetected hypoxic-ischaemic damage to callosal fibres.
Edition employed: TOMI (1984).

Reason for using the test: To assess motor impairment/competence of children born prematurely.
Sample characteristics: 206 children aged 7-10 years, born in London, England. All born preterm (gestational age of 33 weeks or less). Mean Full, Verbal and Performance IQ within the normal range (WISC-R, Wechsler, 1974). Sub-divided according to ultrasound findings on discharge from neonatal unit: (1) Normal (n=112), (2) Uncomplicated Periventricular Haemorrhage (n=55), (3) Ventricular dilatation (n=21), (4) Hydrocephalus (n=5), (5) Cerebral atrophy (n=13).
TEST DATA: Mean total score = 5 (SD: 4). Mean scores for sub-groups: 1 = 4 (SD: 3), 2 = 4 (SD: 3), 3 = 7 (SD: 4), 4 = 5 (SD: 3), 5 = 12 (SD: 4).
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Roth, S.C., Baudin, J., Pezzani-Goldsmith, M., Townsend, J., Reynolds, E.O.R. & Stewart, A.L. (1994).

Relation between neurodevelopmental status of very preterm infants at one and eight years.

Developmental Medicine and Child Neurology, 36, 1049-1062.

Summary
The relation between neurodevelopmental status at one and eight years of age was investigated in a cohort of 207 infants born between 1979 and 1982 at <33 weeks of gestation. The probability of a major disabling impairment at eight years was only 1 per cent for the 43 impaired children and 92 per cent for the 23 of these who had major disabling impairments. Close correspondence was found between the type of major impairment diagnosed at one and eight years. Neurodevelopmental status at one year also predicted the need for extra educational provision by eight years, with probabilities of 9 per cent for children without impairment at one year, 56 per cent for impaired children and 87 per cent for those with major impairments. Similarly, neurodevelopmental status predicted an IQ of more than 2 SD below the mean (<70), with probabilities of 0, 30 per cent and 48 per cent, respectively.
Edition employed: TOMI (1984). Administered by a Paediatrician.
Reason for using the test: To assess motor impairment/competence of children born prematurely.
Sample characteristics: (n=207) aged 8 years (median age = 97 months). Born at <33 weeks gestation without major congenital malformations and who were admitted to the Neonatal Unit of University College London Hospital between 1979-82. Sub-divided according to impairment at one year of age: (1) none (n=164), (2) minor (n=20), (3) major (n=23).
TEST DATA: For total cohort mean = 5 (SD: 4). For groups: 1 = 4 (SD: 3), 2 = 6 (SD: 3), 3 = 11 (SD: 4).
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Ann L. Stewart
Senior Lecturer in Perinatal Medicine, Department of Paediatrics, University College of London Medical School, The Rayne Institute, 5 University Street, London, WC1E 6JJ, U.K.

The Scottish Low Birthweight Study Group (1992).

The Scottish low birthweight study: I. Survival, growth, neuromotor and sensory impairment.

Archives of Disease in Childhood, 67, 675-681.

and

The Scottish low birthweight study: II. Language attainment, cognitive status, and behavioural problems.

Archives of Disease in Childhood, 67, 682-686.

Summary
Of all 908 livebirths weighing less than 1750 g at birth who were born in Scotland in 1984, 896 (99%) were enrolled

in a prospective study to (1) document survival and determine the prevalence of neuromotor and sensory impairments and disability and (2) to determine the prevalence of language, cognitive, and behavioural problems. At the age of 4.5 years, 636 (71%) had survived and 611 (96%) were assessed. Overall 16% were disabled; 47 had cerebral palsy (52.5/1000 livebirths), seven were blind (7.8/1000 livebirths), and 11 were deaf and using aids (12.3/1000 livebirths). Among those not overtly disabled, the prevalence of poor neuromotor competence was high and related to birth weight. All growth measures had mean values below the standard population mean indicating a downward shift in the distribution which was related to birth weight. In addition the height distribution was negatively skewed. Language development was significantly related to birth weight, gestational age and social class for comprehension, less so for expressive language. Mean (SD) intelligence quotient (IQ) on the British ability scales was 92.9 (14.7). Within this population there were no significant differences between birthweight groups. Overall they performed poorly on visual recognition, verbal comprehension and number skills subscales – in the latter those with birth weights <1000 g were significantly worse than the heavier children. Only 5% had IQs <70, but a further 3% could not be tested because of other physical disabilities. Among those with normal IQs were groups of children who exhibited patterns of skill deficits in different subscales raising the possibility of specific learning difficulties. Poor attention span was reported in 47%, and parents said the study children had more behavioural problems than their siblings.

Edition employed: TOMI (1984).

Reason for using the test: To assess the motor impairment/competence of children born of low birth weight (LBW).

Sample characteristics: The total population of children born of LBW (<1750g) in Scotland in 1984 and assessed at 4.5 years (n=611). Mean age = 55.5 months (SD: 2.7). Subdivided on the basis of birth weight: Group 1 (n=60): <1000g, Group 2 (n=298): 1000-1499g, Group 3 (n=253): 1500-1749g. The British ability scales (BAS) were also employed. Intelligence test results (BAS): mean IQ = 92.9 (SD: 14.7). This is lower than the test norm of 100 but not significantly so. There were no statistically significant differences between the mean IQs of the birthweight groups. 5% had IQ scores under 70, 71% scored 85 or more. The mean scores for verbal comprehension, visual recognition and number skill scales were significantly lower than the test standards. Subjects did not differ from the test standards in the proportion of children with scores less than the 10th centile for the subscale of naming vocabulary and in the digit recall. A significantly higher proportion of all subjects scored below the 10th centile on the visual recognition scale and on the verbal comprehension and number skills scales ($p<.001$).

TEST DATA: (For those children without a known neuromotor or visual disability): Percentage of children scoring below 10th centile: Group 1: 40%, Group 2: 20.2%, Group 3: 16.5%, All subjects: 20.3%. The trend by birth weight was statistically significant for the following individual test items: bead threading, one leg balance, jumping over cord. Where there was no trend by birth weight, those in Group 1 performed less well on catching a bean bag and rolling a ball into a goal.

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Yudkin, P.L., Johnson, A., Clover, L.M. & Murphy, K.W. (1995).

Assessing the contribution of birth asphyxia to cerebral palsy in term singletons.

Paediatric and Perinatal Epidemiology, 9, 156-170.

Summary
This geographically-based study investigated the risk of cerebral palsy following intrapartum asphyxia at term and the contribution of intrapartum asphyxia at term to the overall rate of cerebral palsy. Stringent criteria for identifying intrapartum asphyxia were used while recognising that the intitial hypoxial insult might have occurred in the antenatal period. In the first part of the investigation, a cohort of 160 term, singleton infants, with a low (< or equal to 3) 1-minute Apgar score, was followed to the age of 5 years. Six infants in the cohort had

presumed intrapartum asphyxia, of whom two died in the neonatal period, three had spastic quadriparesis, profound developmental delay and visual impairment, and one was unimpaired. The frequency of cerebral palsy associated with birth asphyxia was estimated as one in 3700 full-term livebirths. To assess the impact of birth asphyxia on the overall rate of cerebral palsy, all cases of cerebral palsy born in the study period were identified. Of the 30 cases, the three identified in the follow-up study were the only ones whose impairment could be attributed to birth asphyxia in a full-term birth. Birth asphyxia at term therefore was associated with 10% [95% confidence interval (CI) 2.1,26.5)] of all cases of cerebral palsy and with 20% (95% CI 4.3,48.1) of the 15 cases of cerebral palsy in children born at term.

Edition employed: Movement ABC (1992).

Reason for using the test: To measure the degree of motor impairment/competence in children born with birth asphyxia.

Sample characteristics: 158 term (> or equal to 37 weeks) singleton infants born at the John Radcliffe Hospital, Oxfordshire, England 1984-1985. 1-minute Apgar score < or equal to 3. Exhibited specified hypoxic signs.

TEST DATA: Not reported.

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Section 3 Intervention Studies

The *TOMI/Movement ABC* has been used to evaluate the effectiveness of interventions of various sorts. These range in nature from the very specific thrust of a remedial program designed around a narrow hypothesis concerning the processing deficit responsible for DCD to an eclectic approach which draws pragmatically upon various loosely motivated techniques currently employed by therapists.

In describing the types of intervention offered to children with DCD, a broad distinction may usefully be drawn between 'process-oriented' and 'task-oriented' approaches, although at the limit these concepts are neither exhaustive nor mutually exclusive. Whereas a 'process-oriented' approach attempts to identify and treat the putative underlying deficit (or deficits) held responsible for the child's motor difficulties, 'task oriented' approaches are not predicated upon a model of the essential components of movement skills and their malfunction in children with DCD. They attempt, instead, to focus remedial efforts directly on those skills of daily life that the child lacks.

For some time, the 'process-oriented' approach favored by occupational therapists has been that proposed by Jean Ayres and commonly known as Sensory-Integration (SI) therapy. For whatever reason, none of the advocates of that approach have used the *TOMI* or the *Movement ABC*. The only study that uses *TOMI* to evaluate SI therapy is one of the few in this corpus to evaluate more than one therapy. Polatajko et al's interesting study also attempts to assess the approach vigorously promoted by Laszlo and her colleagues, in which a deficit of kinaesthetic sensitivity is held to be the defective process responsible for most cases of DCD. In this annotation, we present Laszlo et al's original investigation of the efficacy of her approach followed by three other studies which in different ways fail to find support for it.

Schoemaker's study can be used to illustrate a number of the key factors that might be used to classify the studies in this section. She took as her starting point the procedures typically applied by therapists in the Netherlands. While for the most part these procedures invite the label 'task-oriented', elements such as those derived from Bobath therapy are a mixture of process and task-orientation. This kind of study neither aims at the testing of a causal model nor attempts to identify the most effective therapeutic techniques. It's objectives are better described as an attempt to optimise the management of procedures already in use in a particular context.

Turning now to matters of design, most of the studies included in this annotation meet the basic requirement of employing an untreated control group. However, the nature of this group varies. In the typical study, all subjects are drawn from the DCD population and are divided into two or more groups, one of which receives no intervention (Laszlo & Bairstow, 1988, Sims 1996a, b; Polataijko et al, 1992). However, subjects are assigned to groups in different ways and the extent to which they are matched varies considerably. A few studies of this sort incorporate a cross-over manipulation in which all children eventually receive intervention. This allows the primary between-groups comparison to be supplemented by a within-subject comparison albeit usually without the benefit of a counterbalanced design. In contrast, Schoemaker et al. (1994) employ a completely different sort of design in which the impaired children in the study act as their own controls. This study involved the following sequence of events. An initial assessment was followed by a period of 3 months without intervention whereupon a second assessment was made. After a further 3 months during which intervention took place, a third assessment was conducted. Meanwhile, a group of unimpaired children underwent the same schedule of assessments without any intervention, providing an additional measure of the effects of maturation on performance.

The amount of detail provided on the children participating in these studies varies considerably. As noted in Section One, the lack of universal agreement concerning the criteria for DCD is reflected in the diversity of methods used to select subjects. At one polarity, we find studies involving highly selected subjects with IQs

above 85, *TOMI* scores below the 5th percentile and clearly specified exclusion criteria. At the other, we find studies using the laxer 15th percentile as the criterion for motor impairment with no other exclusions or constraints.

The time scale on which these studies have been constructed also varies considerably, both with regard to the intervention period and the duration of any follow up. This form of variation probably reflects the uncertainty that surrounds the relative merits of a brief period of intensive intervention versus a more protracted but less concentrated timetable. Yet another variable is the duration of sessions which vary from 20 to 45 minutes in length. Where a follow up evaluation has been included, the delay never exceeds 6 months.

The *TOMI/Movement ABC* is not the only battery used in these studies and interesting comparisons can often be made. For example, sometimes a so-called process-oriented test is used to determine whether the treatment has had the desired effect on the putative deficit of interest, with the *TOMI/Movement ABC* acting as the index of generalization to every day life functioning. At other times, the *TOMI/Movement ABC* is the objective measure with parent and/or teacher rating acting as the more "ecologically valid" indicator of change. These other assessments include standardised tests such as the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978), Laszlo and Bairstow's Kinaesthetic Sensitivity Test (KST) and Perceptual-Motor Abilities Test (PMAT, Laszlo & Bairstow, 1985), the Developmental Test of Visual-Motor Integration (Beery, 1982) and the Southern California Sensory Integration Test (SCSIT, Ayres, 1972); as well as less formal procedures in which children's drawing and handwriting are examined or teachers and parents views are solicited.

In our view, this body of work considered as a whole, offers very little encourage-ment to those who yearn for a magical "cure" for DCD nor does the evidence bear in an important way on the attempt to understand the condition. Even the modest objective of identifying relatively more effective interventions is not well served by this literature. Moreover, even those studies able to detect improvements scarcely diminish our uncertainties about possible sources of improvement. On the positive side, this corpus of studies has played a role in persuading us that "clumsy" children can be helped to cope with their difficulties, although the effects reported are small, often insecure, and have not yet been shown to persist.

Laszlo, J., Bairstow, P. & Bartrip, J. (1988).

A new approach to treatment of perceptuo-motor dysfunction: previously called 'clumsiness'.

Support for Learning, 3 (1), 35-40.

the same study was also reported in:

Laszlo, J.I., Bairstow, P.J., Bartrip, J. & Rolfe, U.T. (1988)

Clumsiness or perceptuo-motor dysfunction?

In A.M. Colley and Beech, J.R (Eds.) *Cognition and action in skilled behaviour*. Advances in Psychology No. 55. North-Holland: Elsevier Science Publishers. P 293-309.

Summary
The aim of the study was to assess the efficacy of a particular 'process orientated' approach to intervention. Forty children attending mainstream Junior schools were selected by their teachers as having motor development that lagged behind their intellectual abilities. The Perceptual-Motor Abilities Test (PMAT; Laszlo and Bairstow, 1985) was used to identify the specific processes at which the child was deficient and the Test of Motor Impairment to obtain a global index of impairment. The children were randomly allocated to one of 4 training groups for 1.5-3.00 hours over two weeks. Group 1 were trained in all processes in which they had been found to be deficient. Group 2 were trained in kinaesthesis only, although they had been found to be deficient in spatial and/or temporal programming. Group 3 were trained in spatial and/or temporal programming only, although they had been found to be deficient in kinaesthesis also. Group 4 received general fine and gross motor skill training along traditional lines. Composite scores on the PMAT and TOMI revealed that there were initially no significant differences between the groups. When re-tested on the PMAT and TOMI after completion of training

it was found that groups 1 and 2 were within the normal range for their age but groups 3 and 4 had not improved. Group 3 was then re-trained in kinaesthesis only and group 4 on all processes in which they were deficient. When re-tested on the PMAT and TOMI after training, groups 3 and 4 were found to have improved.
Edition employed: TOMI (1984).
Reason for using the test: To assess motor impairment/competence of children with delayed motor development before and after training.
Sample characteristics: 40 children (31 boys, 9 girls) with mean age = 9,3 (Range: 7.5-11.5) all attending mainstream junior schools in the Greater London area. Initially selected by teachers for motor development that lagged behind intellectual abilities, the children represented the full range of intellectual abilities and varied both in ethnic origin and socioeconomic status. They were considered to be representative of the school as a whole. On the PMAT, error scores were above 1SD from the mean score for age. Children with the highest four rank scores were allocated randomly to four groups, those with the next highest rank scores were allocated similarly and this procedure was repeated until all subjects had been placed into four groups. Areas of deficiency were identified by performance on the PMAT. Only those with high error scores on kinaesthetic acuity and/or kinaesthetic perception and memory were placed in groups 2 and 3. In the first phase of the study Group 1 was trained in all areas in which they were found to be deficient, Group 2 were only given kinaesthetic training (although they had performed poorly in spatial and/or temporal programming as well). Group 3 were given only spatial and/or temporal programming, no kinaesthetic training. Group 4 had practice in fine and gross motor skills, which was not related to their diagnosed deficiencies. In the second phase of the study Group 3 was re-trained in kinaesthesis only and Group 4 on all processes in which they were considered deficient.
TEST DATA: Test scores were gathered pre-intervention, and at the end of phases one and two. No figures are provided. It is stated that pre-intervention there were no significant differences between the groups and that the TOMI results mirrored those from the PMAT. There was a significant correlation between the two tests (pre-intervention Spearman rho = 0.655, $p < 0.001$, N=40; post-intervention Spearman rho = 0.660, $p < 0.001$, N=40). At the end of phase one groups 1 and 2 were within the normal range for their age but groups 3 and 4 had not improved. Results for groups 1 and 2 and for groups 3 and 4 were combined. There was significant improvement for groups 1 and 2 only.(Wilcoxon's matched pairs signed-ranks test n=18 T=31.5, $p<0.01$). At the end of phase two groups 3 and 4 were found to have improved.
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Polataijko, H.J., Macnab, J.J., Anstett, B., Malloy-Miller, T., Murphy, K. & Noh, S. (1995).

A clinical trial of the process-oriented treatment approach for children with developmental co-ordination disorder.

Developmental Medicine and Child Neurology, 37, 310-319.

Summary
The process-oriented treatment approach is a time-limited programme aimed at increasing the kinaesthetic performance of children with mild motor problems in order to improve their motor performance. This approach was compared with a traditional or general motor approach and with no treatment in a randomized clinical trial of 75 children with developmental co-ordination disorder. The children were assessed before and after treatment and after a six-week follow-up period. The results were mixed. The study provides evidence of the severity of so-called 'mild' motor problems of children referred for occupational therapy. The data suggest that these children do not improve spontaneously and that their motor problems are very resistant to treatment. The data also suggest that an appropriate treatment strategy might be one than involves direct, repetitive training of a specific skill.
Edition employed: TOMI (1984).
Reason for using the test: To assess and compare motor impairment/competence of three groups of children with DCD pre-treatment and after a follow-up period of 6 weeks.

Sample characteristics: Seventy six children (54 boys, 22 girls) aged 7-12 years old (mean = 9.06 years) drawn from children referred to a 'Home Care School Health Support Program'. All had normal intelligence (Verbal or Performance IQ at least 85). All had motor problems, scoring less than or equal to -1 standard deviation on the fine motor, gross motor or composite scores of the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) and had a deficient performance rating on the tasks of Ayres' clinical observations (Ayres, 1972). Hearing and vision (or corrected vision) were within normal limits. None had or were receiving occupational or physical therapy for their motor problems. None had a diagnosis of specific neurological disorder, physical or sensory deficit. They were randomly assigned to one of three intervention groups: Process Oriented (PO) (n=26) received kinaesthetic training as described by Laszlo & Bairstow (1985) for 12 sessions over about 5 weeks or until the task was performed to criteria. Traditional (TRAD) (n=24) received Occupational Therapy programmes designed to meet their specific motor needs for approximately 15 weeks (treatment consisted of a combination of a variety of Sensory Integrative, gross and fine motor and perceptual-motor activities). No treatment (NONE) (n=24) did not receive any therapy for their motor problems for an 11-week period.
TEST DATA: Test scores were gathered pre-intervention, immediately after intervention and finally 6 weeks after intervention. At pre-test, total TOMI score for the whole sample = 8.72. For sub-tests: Manual Dexterity Scores – PO group mean = 3.19 (SD: 1.63), TRAD group mean = 3.77 (SD: 1.86), NONE group mean = 3.40 (SD: 1.74). Ball Skills scores – PO group mean = 2.46 (SD: 1.39), TRAD group mean = 1.77 (SD: 1.42), NONE group mean = 1.94 (SD: 1.17). Balance scores – PO group mean = 3.38 (SD: 1.91), TRAD group mean = 3.12 (SD: 1.51), NONE group mean = 3.10 (SD: 2.16). No significant group differences were found on any of the three sub-tests. TOMI results at follow-up six weeks after the end of treatment: Manual Dexterity scores – PO group mean = 3.27 (SD:1.57), TRAD group mean = 3.27 (SD:1.64), NONE group mean = 3.50 (SD:1.61). Ball Skills scores – PO group mean = 2.17 (SD: 1.36), TRAD group mean = 1.48 (SD: 1.23), NONE group mean = 2.15 (SD: 1.35). Balance scores – PO group mean = 3.19 (SD: 1.64), TRAD group mean = 3.02 (SD: 1.33), NONE group mean = 2.89 (SD: 1.69). No significant differences were found on any of the three sub-tests either between the groups or across time (pre-test, post-test and follow-up).

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Schoemaker, M.M., Hijlkema, M.G.J. & Kalverboer, A.F. (1996)

Physiotherapy for clumsy children: An evaluation study.

Developmental Medicine and Child Neurology, 36, 143-155.

Summary
This paper reports the findings of an evaluative study of physiotherapy for clumsy children. 18 children were identified by school doctors as having poor motor co-ordination. They were followed for three months in order to exclude spontaneous improvement of motor problems; none spontaneously improved. Subsequently, these children were enrolled on a regular physiotherapy programme. Treatment was administered individually twice a week over three months. The effects of treatment for clumsy children appeared to be promising: important improvements were found on various motor skills. These benefits were maintained for a three-month period after the end of treatment.
Edition employed and profession of tester: TOMI (1984). Administered by a research psychologist.
Reason for using the test: To select subjects and compare motor impairment/ competence before and after treatment.
Sample characteristics and control procedures: Index group: 17 children (14 boys, 3 girls) with mean age = 7,4 (Range: 6,1-9 years). All attended mainstream school and had not previously been treated for their motor problems. Identified by school doctors when they failed on more than one item requiring motor competence. All scored below the 5th centile on the TOMI and showed no evidence of a gross neurological disorder when assessed by a neurologist. Control group: selected by school doctors, having passed the motor tests in the school medical examination. None had physical or sensory problems. All performed within the normal range on the TOMI, scoring

below 4.5. Matched for age and sex with index group. Mean age=7,4 (Range: 6-9,1). All children were also tested on the ABC (General Motor Coordination Test; Wiegersma et al., 1988).
TEST DATA: Test scores were gathered on two occasions prior to intervention and once again following the three-month intervention period. No significant difference was found between the first and second pre-test TOMI scores for the index group ($F(1,15)=0.04$, $p<=0.85$). On the pre-test just before treatment, significant differences were found between index children and controls on all the sub-tests of the TOMI. Differences between the two groups were significant at p=.01 for norm scores for each of the eight items (means and standard deviations of norm scores are provided). Non-parametric correlation between scores of the TOMI and the ABC test (Wiegersma et al., 1988) were significant for the total scores ($r=0.85$, $p<.01$), for 'moving one hand rapidly' ($r=0.74$, $p<.01$), 'moving both hands rapidly' ($r=0.55$, $p=0.02$) and 'balance beam' scores ($r=0.52$, $p=0.01$). 15 of the 18 children who scored badly on the TOMI also scored badly on the ABC. There was a significant interaction between group and treatment for TOMI scores ($F(1,16)=39.59$, $p<.01$) with the index group improving performance and the control group remaining the same (individual data is provided). In the index group 8 children improved from 'deviant' to 'borderline' or 'normal' performance, and one moved from 'borderline' to 'normal'. 8 children remained in the 'deviant' category although performance on the TOMI improved by an average of 2.7 points. 6 of these children continued to be treated, all had a pre-test score ≥ 9. Thus the pre-test TOMI score was considered to be a reliable indicator of the seriousness of clumsiness and thus a predictor of the required length of treatment. Mean norm scores are provided for both groups for each of the eight TOMI items. For 3/8 items the index group improved more than the control group between pre- and post-test ('speed and coordination of the two hands', catching ball, static balance). There was no significant difference between TOMI scores for the index group between post-test and follow-up ($F(1,19)=0.58$, $p=0.47$) indicating they maintained improved performance for up to three months but did not improve further.

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Schoemaker, M.M., Schellekens, J.M.H. & Kalverboer, A.F. (1994)

Effects of short-term physiotherapy on the handwriting proficiency of clumsy children.

In: C. Faure, P. Kews, G. Lorette & A. Vinter (Eds*) Advances in handwriting and drawing: A multidisciplinary approach*. Paris: Europia Press.

Summary
The aim of this study was to evaluate the effects of treatment on the handwriting problems of clumsy children, using both a descriptive motor test as well as a kinematic analysis of stroke production in handwriting. Positive effects of intervention were obtained for general motor skills as well as for stroke production in a drawing task. After treatment, clumsy children drew faster, more fluently, and with less time-consuming pauses between strokes. Accuracy of drawing did not improve. This led to the conclusion that kinematic analysis techniques are more sensitive to treatment effects than outcome oriented measures of motor functioning alone.
Edition employed: TOMI (1984).
Reason for using the test: To select subjects and compare motor impairment/competence before and after treatment.
Sample characteristics and control procedures: Index group: 17 children (14 boys, 3 girls) with mean age=7,4 (Range: 6,1-9 years). All attended mainstream school and had not previously been treated for their motor problems. Identified by school doctors when they failed on more than one item requiring motor competence. All scored below the 5th percentile on the *TOMI* and showed no evidence of a gross neurological disorder when assessed by a neurologist. Control group: selected by school doctors, having passed the motor tests in the school medical examination. None had physical or sensory problems. All performed within the normal range on the

TOMI, scoring below 4.5. Matched for age and sex with index group. Mean age=7,4 (Range: 6-9,1). One pair was excluded as an index child dropped out.

TEST DATA: Test scores were gathered on two occasions prior to intervention and once again following the three-month intervention period. There were significant differences between the index and control groups on all sub-tests of the *TOMI* before treatment. There were no differences between *TOMI* scores in the first and second pretest ($p<.85$). Comparison of *TOMI* scores at the start of treatment and after three months of treatment yielded a significant interaction between group and treatment ($F(1,16)=39.59$, $p<.01$). The 'clumsy' group had improved while the control group remained the same. On manual dexterity items there was a significant improvement on the item assessing speed and coordination of both hands ($p<.05$) and a trend towards significance for the item assessing speed of single hand movements ($p<.10$). No significant improvement was found on the item assessing pencil control.

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Sims, K., Henderson, S.E., Hulme, C. & Morton, J. (1996)

The remediation of clumsiness. I: An evaluation of Laszlo's kinaesthetic approach.

Developmental Medicine and Child Neurology, 38, 976-987.

Summary
The effectiveness of a kinaesthetic training programme proposed by Laszlo for children with movement difficulties was evaluated by comparing two groups of 10 'clumsy' children matched pairwise on age, IQ and sex as well as degree of kinaesthetic and motor impairment. Tests of kinaesthetic ability, using the Parameter Estimation by Sequential Testing (PEST) procedure, and motor competence administered before and after treatment revealed an improvement in both groups on all measures but no differential effect of the training programme. Immediately after training, the changes obtained in motor performance were confined to balance skills but, at follow up, 3 months later, changes in manual and ball skills were also evident. This unusual pattern of change requires replication. The findings suggest that any effect of Laszlo's recommended training programme might have been obscured by our use of the PEST procedure, which had in itself facilitated motor learning.

Edition employed: TOMI (1984).

Reason for using the test: To select subjects and compare motor impairment/ competence before and after treatment.

Sample characteristics and control procedures: 20 children (14 boys, 6 girls) with mean age = 8,10 (Range: 8-9,11), considered by teachers to have 'poor coordination for their age that was affecting their schoolwork'. There was no evidence of medical or other conditions and they scored below the 15th centile point (<3.5) on the TOMI. 18 failed both components of the KST(using the method of constant stimuli), 2 failed on the kinaesthetic perception and memory component only. Verbal IQ was at least 70 on the short form of the WISC-R. They were randomly assigned on a pair-wise basis to two groups, A and B. Chronological age, sex, PEST and TOMI scores were used as matching criteria. There was no difference between the groups on KST, TOMI or Verbal IQ scores. In the first phase of the study, group A received kinaesthetic training for 20-25 minutes for 10 days and group B received no intervention, attending school in the normal way. In the second phase of the study the groups were crossed over so that group B then received kinaesthetic training.

TEST DATA: Test scores were gathered pre-intervention, at the end of phases one and two and finally 3 months after intervention. Pre-intervention total TOMI scores were: Group A mean = 8.4 (SD:3.6), Group B mean = 7.1 (SD: 2.6). There was no significant difference between the groups ($F=0.81$). No figures are provided for pre- vs. post-intervention but the results are plotted on a graph. TOMI scores improved significantly from pre-intervention to the end of phase one, when group A had received training but group B had not, ($F(1,28)=24.47$. $p<.001$). There was no effect of group ($F=0.28$) and no significant interaction ($F=1.28$). Wilcoxon's signed ranks tests revealed the greatest improvement in balance ($z=2.5$, $p<.05$). (Changes in manual dexterity and ball skills did not reach statistical significance). There was no further

improvement of scores for group B at the end of phase two, when they had received training. At follow up, mean TOMI scores for group A were 3.5 and group B 4.4. Taking both subject groups together this further decrease was statistically significant (Wilcoxon N=16, z=2.24, p<.05). Significant progress had been made in all three sections of the test (manual dexterity, z= -3.52, p<.0005; ball skills z=-2.09, p<.05; balance z=-2.93, p<.005). While half of the subjects had now progressed above the 20th centile on the test, some had still not reached the level of motor competence achieved by their well coordinated peers.

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Sims, K., Henderson, S.E., Hulme, C. & Morton, J. (1996)

The remediation of clumsiness. II: Is kinaesthesis the answer?

Developmental Medicine and Child Neurology, 38, 998-997.

Summary
This paper reports the second of two studies designed to evaluate the effectiveness of the Kinaesthetic Training Programme (Laszlo and Bairstow, 1985) for children with movement difficulties. Three groups of 12 children were matched on age, IQ and sex as well as degree of kinaesthetic and motor impairment. One group received the Laszlo training, another received a training programme designed to avoid explicit reference to kinaesthesis and the third group received no training. Children receiving no intervention failed to show a change in performance. By contrast, the motor competence of both groups of treated children improved significantly. There was no advantage for the Laszlo trained group. It seems that in designing a remediation programme for clumsy children, the way that training is presented is as important as its actual content.

Edition employed: TOMI (1984).

Reason for using the test: To select subjects and compare motor impairment/ competence before and after treatment.

Sample characteristics and control procedures: 36 children (29 boys, 7 girls), referred from three hospital clinics specializing in the treatment of children with developmental disorders and from 11 mainstream schools in London, U.K. None had a known neurological or other medical condition. All scored below the 5th centile on the TOMI, below the 25th centile on both components on the KST and had Verbal IQs greater than 85 on the short form of the WISC-R. Chronological age, sex, verbal IQ, KST scores and TOMI scores were used as matching variables to produce sets of three children who were randomly allocated to two treatment groups A and B and a control group, C. Mean Age: A= 8.2 years (SD: 0.9), B=8.0 years (SD: 1.0), C=8.2 years (SD: 1.4). Mean Verbal IQ: A=109.9 (SD: 13.4), B=105.9 (SD: 15.2), C=104.7 (SD: 13.2). Mean TOMI: A=7.8 (SD: 2.1), B=7.6 (SD: 2.8), C=8.2 (SD; 3.1). There was no significance difference between the groups on TOMI, Verbal IQ or KST scores. Group A received the kinaesthetic training programme prescribed by Laszlo and Bairstow (1985). Group B received 'cognitive-affective' training on three tasks: pursuit-rotor, drawing and miming. Group C were not given any intervention.

TEST DATA: Test scores were gathered pre-intervention and following the two-week intervention period. There was no change in TOMI scores for group C (z=1.13). There was a significant improvement in TOMI scores for groups A and B (z=2.8, p<.005 and z=2.43, p<.05 respectively). Improvements were only significant for the balance tasks (z=2.6, p<.05 and z=2.4, p<.05). A Mann-Whitney U test failed to show a significant difference between the two groups (U=64.5).

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Wright, H.C & Sugden, D.A. (1995).

Management of children aged 6-9 years with Developmental Coordination Disorder.

In: I Morisbak & P.E. Jorgensen (eds.). ISAPA, 95: Quality of Life through Adapted Physical Activity and Sport. 10th Symposium Conference Proceedings, ISAPA.

Summary
Eighteen children with Developmental Coordination Disorder (DCD), originally identified by their teachers and confirmed by the results of the Movement ABC, took part in a five week intervention study. The management of the children's motor difficulties was carried out by their school teachers during curriculum time. The operational guidelines and suggested activities were derived from the Movement ABC guidelines for intervention and in consultation with the teachers. The individual profiles of the children improved post-intervention suggesting that the management of DCD can take place profitably in a school setting once detailed and specific individual planning has been done.

Edition employed: Movement ABC (1992). The Test (administered by a researcher), Checklist (administered by teachers with some training in the teaching of Physical Education) and Guidelines for Intervention were used.

Reason for using the test: To obtain an objective measure of motor impairment/competence, to plan a program of intervention and to evaluate the effectiveness of that intervention.

Sample characteristics and control procedures: Eighteen 6-9 year old children (10 boys, 8 girls) with DCD from three primary schools in Singapore. All were considered by their teacher to have movement difficulties which were holding them back at school. All obtained scores below the 15th percentile on either the Test or the Checklist.

TEST DATA: Test scores were gathered pre-intervention and following the five week intervention period. All 18 of the children had lower post-test scores on the Movement ABC Test (average scores 16.03 vs. 8.22) which represented a significant difference ($t=7.69$, $df=17$, $p<.001$). 16 of the 18 also had lower Checklist scores which also represents a statistically significant difference ($t=4.48$, $df=17$, $p<.001$). The authors illustrate the individual variation, with some children improving a lot and others only a little.

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Section 4 Test Development qnd Psychometric Properties

As with other tests, the development of the *TOMI/Movement ABC* is an ongoing process involving revision and the updating of norms. The current manual of the *Movement ABC* contains a substantial chapter dealing with the psychometric properties of the **Test** and the **Checklist**. Much of this material has not been published and therefore should be consulted in and ascribed to that source. Only studies of reliability or validity that have been separately published and contain more detailed information or more extended discussion have been included here.

Since its publication in 1992, the *Movement ABC* has grown in popularity and the test is now being employed on every continent. Over the next year or two several translations are likely to be published in Europe and in Asia and in many cases these will carry their own local norms. In view of the time it takes for a study of the sort dealt within this section, to be developed from the flicker of an idea in the author's mind to archival status on the printed page, we have appended a selective list of the names and addresses of researchers who are currently engaged in substantial studies of the **Test** or **Checklist** and who have declared an interest in communicating with others working on similar topics.

Causgrove Dunn, J. & Watkinson, E.J. (1996).

Problems with identification of children who are physically awkward using the TOMI.

Adapted Physical Activity Quarterly, 13, 347-356.

Summary

This study was designed to investigate a claim made by Causgrove and Watkinson (1993) that the TOMI may be biased in favour of boys. In the original study, Causgrove and Watkinson (1993) showed that an unexpectedly high proportion of girls from Grades 3 to 6 were identified as physically awkward. In the present study, this suggestion was investigated through comparison of performances of TOMI subtest items by boys and girls from Grades 1 to 6. Chi-square analyses on each of the eight test items revealed significant performance differences between boys and girls on the two ball skills tasks of catching and throwing ($p<.0001$) at Age Bands 3 and 4; a significantly greater proportion of boys than girls age 9 to 12 years passed the catching and throwing tasks. A significant performance difference was also found on the tracing task at Age Band 1, with more girls passing tracing than boys. Implications for future research requiring the identification of children who are physically awkward are discussed.

Edition employed and profession of testers: TOMI (1984). Administered by graduate or senior undergraduate students in physical education.

Reason for using the test: To examine test content with regard to gender bias.

Sample characteristics: n = 597 (295 boys, 302 girls) aged 6-12 years (Mean: 9.05, SD: 1.72) from four schools in a Western Canadian city. 63 tested at Age Band 1, 160 at Age Band 2, 231 at Age Band 3 and 143 at Age Band 4.

TEST DATA: Mean total scores: Boys = 1.95 (SD: 1.80), Girls = 2.34 (SD: 2.09).3.4% of boys and 8% of girls scored 6.0 + (indicating a 'definite' motor problem), 10% of boys and 14.3% of girls scored 4.0-5.5 (indicating a 'moderate' motor problem).
Significantly more boys than girls passed the ball skills tasks at Age Bands 3 and 4:
Age Band 3: Catching X^2 (1,231) = 34.75, $p<.0001$; throwing X^2 (1,230) = 20.55, $p<.0001$.
Age Band 4: Catching X^2 (1,143) = 15.73, $p<.0001$; throwing X^2 (1,142) = 21.54, $p<.0001$.
Significantly more girls than boys passed the tracing tasks at Age Band 1: X^2 (1,63) = 11.20, $p<.006$.

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Riggen, K.J., Ulrich, D.A. & Ozmun, J.C. (1990).

Reliability and concurrent validity of the Test of Motor Impairment – Henderson Revision.

Adapted Physical Activity Quarterly, 7, 249-258.

Summary
The reliability and concurrent validity of the TOMI was evaluated employing a sample of American preschool children. Absolute reliability of the final test score was established by calculating the standard error of measurement (SEM). An SEM of .86 was obtained. The consistency of decisions related to motor impairment or non-impairment was estimated by calculating both the 'proportion of agreement index' across two testing occasions and Kappa coefficients. A 90% agreement was obtained with Kappa equal to .71. Concurrent validity using the Bruininks-Oseretsky Test of Motor proficiency – Short Form (BOTMP-SF) as the criterion resulted in an 88% agreement between the two tests.
Edition employed and profession of testers: TOMI (1984). Administered by a faculty member and research students in physical education.
Reasons for using the test: To investigate the reliability and concurrent validity of the test.
Sample characteristics: 41 children (20 boys, 21 girls) from three preschools in a Midwest University community. Mean age = 5.8 years (SD: 0.49 years). Most from middle socioeconomic-income families, although low and high levels were also represented. Interval of time between the two testing occasions employing the TOMI ranged from 4 to 7 days.
TEST DATA: The 15th percentile was employed for both the TOMI and BOTMP-SF to indicate motor impairment. The SEM for absolute reliability of the final test score was 0.86. The proportion of observed agreement in non-impairment or impairment decisions across the two testing occasions was 90% and Kappa was equal to 0.71. The proportion of observed agreement in non-impairment or impairment decisions made employing the TOMI and the BOTMP-SF was 88% and Kappa was equal to 0.57.
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Sugden, D. & Sugden, L. (1991).

The assessment of movement skill problems in 7- and 9-year old children.

British Journal of Educational Psychology, 61, 329-345.

Summary
This paper describes one of the key studies in the development of the Movement ABC Checklist. Teachers completed checklists on 350 seven-and nine-year-old children. Developmental differences were shown on every section of the Checklist, and in the bottom 10 per cent of scores boys outnumbered girls by a ratio between 2 and 3 to 1. The nature of movement problems was examined by analysing profiles of children identified by the Checklist, and the resulting profiles suggest there is a need to move away from viewing children with movement problems as an homogenous group.
Edition employed: TOMI (1984) and the Checklist.
Reason for using the test: TOMI used to assess validity of the Checklist. Checklist used to examine effects of age and gender.
Sample characteristics: Children aged seven years and nine years from 25 primary schools in a large city in the North of England. Five schools were randomly selected from each of five zones within the authority of the city, ranging from inner city to the suburbs. In each school, two classes were chosen: one with children aged 6-7 years, one with children aged 8-9 years. Random sample (n=300, 75 boys, 75 girls in each age group on the Checklist; n=48 on TOMI): in each of the classes three boys and three girls were randomly chosen from the class list. In each age group, children with the lowest 5% scores on the Checklist were then tested on the TOMI, then those in the next lowest 5%. A further 5% of children from those who were not in the bottom 10% were randomly selected. Selected sample (n=50 on the Checklist; n=30 on TOMI): every class teacher was asked to pick out the child he/she believed to have most difficulty with

movement skills. In each age group the bottom 10 (20%) were selected, followed by 5 (10%) randomly drawn from the remainder. The teachers were shown how to use the checklists, which were then left with them for approximately 3 weeks. One month after the checklists had been returned, each teacher (n=50) was given one checklist to complete again on one child. 39 were returned.

TEST DATA: Checklist results: Random sample mean scores: 7 year-old boys: Section 1 = 21.58, 2 = 21.71, 3 = 21.14, 4 = 19.60, total = 85.03, 5 = 15.66. 7 year-old girls: 1 = 17.94, 2 = 19.63, 3 = 20.97, 4 = 18.60, total = 77.14, 5 = 13.59. 9 year-old boys: 1 = 17.68, 2 = 18.72, 3 = 16.60, 4 = 16.00, total = 69.00, 5 = 14.67. 9 year-old girls: 1 = 14.69, 2 = 17.16, 3 = 16.10, 4 = 14.80, total = 62.75, 5 = 11.34. Reliability of the Checklist: Pearson product moment correlations were performed on the scores obtained in each of the five sections, on the total of sections 1-4 and on the total of all sections. All correlations were signficant at the 1% level, except scores of 9 year-old girls on section 3 which were significant at the 5% level. Validity of the Checklist: In 7 year-old group: 5/8 (62.5%) at bottom 5% of the Checklist, 5/8 (62.5%) were impaired or borderline on the TOMI. In the next 5%, 3/8 (37.5%) were impaired or borderline on the TOMI, 8/16 (50%) impaired or borderline on both assessment instruments. In the sample scoring adequately on the Checklist only 1/8 (12.5%) was borderline on the TOMI.

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Wright, H.C., Sugden, D.A., Ng, R. & Tan, J. (1994).

Identification of children with movement problems in Singapore: Usefulness of the Movement ABC Checklist.

Adapted Physical Activity Quarterly, 11, 150-157.

Summary
This investigation is concerned with the identification and assessment of Singaporean primary children who have Developmental Coordination Disorder. The study forms part of a larger project concerned with the suitability of currently available assessment techniques and intervention programs for use in Singapore. In this paper the usefulness of the Movement ABC Checklist and Test as an assessment instrument is explored. The data on a sample of 212 7- and 8- year olds compared favorably with data from the standardization sample in the United Kingdom. Age and gender differences were similar, and the effects of increasing task difficulty within the Checklist were generally confirmed. The checklist identified 15.6% of children as having movement problems or being at risk, which was close to the value obtained in the U.K. The Movement ABC Test provided evidence of the validity of this figure as it successfully differentiated the selected children from age-matched controls who scored well on the Checklist. Although some of the items in both instruments need modification, the results suggest that the Movement ABC package is a workable research tool in the Singaporean context.

Edition employed and profession of testers: Movement ABC (1992), both the standardized Test and the Teacher's Checklist. A qualified Physical Education teacher administered the Test. The Checklist was completed by class teachers.

Reason for using the test: To identify children with movement impairment. To compare data from Singaporean children to that from the U.K. standardization sample.

Sample characteristics and control procedures: 212 Singaporean children, 58 boys and girls aged 7 years and 46 boys and 50 girls aged 8 years.

TEST DATA: Test re-test Reliability of Checklist: After two weeks, 50% of the Checklists (120) were completed again on the same children. All correlations for the component sections were significant at the 5% level (range .33-86) except for 8 year old girls on Section 2. Comparison of Singaporean and U.K. data: All Singaporean children scored within a similar range to the U.K. sample and (except 7 year old girls) the pattern of scores across sections was similar to that from the U.K. data. A main effect of gender showed girls to perform better than boys ($F=4.35$, $df=1.208$, $p< .05$). There was a main effect of section, with no significant interactions ($F=43.99$, $df=3.624$, $p< .000$). Tukey's paired comparisons showed significant differences between all sections ($p< .05$). Means for each section were: 1=4.25, 2 = 5.51, 3= 6.7, 4= 7.64. For 7 year old girls the poorest scores were in section 3 rather than in section 4.

Pearson product moment correlations between section 5 and sections 1-4 ranged from .24 ($p<.05$) for 7 year old girls to .62 ($p<.01$) for 8 year old boys. Identification of children with movement problems: 4.72% of the sample scored below the 5th percentile established by the U.K. sample. 10.85% scored below the 15th percentile. When these children with movement problems and matched controls who had no motor problems on the Checklist were tested on the Test there was a significant difference ($p<.01$).

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Other studies relevant to this section:

Wright, H.C. & Sugden, D.A. (1996). A two-step procedure for the identification of children with Developmental Co-ordination Disorder in Singapore. *Developmental Medicine and Child Neurology*, 38, 1099-1105. Includes information on reliability of the Checklist (see Section One).

Contacts around the World

Below we provide a list of those countries outside the U.K., where we know of people who are working with the test. We include the names and addresses of people who may be contacted if you are interested in using the test in these countries. We have also provided details of published translations of the test into different languages.

CHINA
Contact: Susanna Chow, Department of Rehabilitation Sciences, Hong Kong Polytechnic University, Hung Hom, Hong Kong.

DENMARK
Contact: Hans Gerhardt, Danish Psychological Publishers, Hans Knudsens Plads 1A, DK-2100 Kobenhavn O.
Danish Translation: Henderson, S.E. and Sugden, D.A. (Danish Translation, 1997). *Movement Assessment Battery for Children.* Copenhagen: Dansk Psychologisk Forlag.

FINLAND
Contact: Libbe Kooistra, Department of Psychology, University of Jyväskylä, P.O. Box 35, 40351 Jyväskylä, Finland or Marja Cantell, Department of Physical Education, University of Jyväskylä, P.O. Box 35, 40351 Jyväskylä, Finland.

JAPAN
Contact: Motohide Miyahara, School of Physical Education, University of Otago, P.O. Box 56, Dunedin, New Zealand or Masatsugu Tsujii, Gifu Shoutokugakuen University, Japan.

SWEDEN
Contact: Birgit Rösblad, Department of Psychology, University of Umeä, S-90187 Umeä, Sweden.
Swedish Translation: Henderson, S.E. and Sugden, D.A. (Swedish Translation, 1996). *Movement Assessment Battery for Children* (Rorelsetest for barn). Stockholm: Psykologiforlaget.

THE NETHERLANDS
Contact: Bouwien Smits-Engelsman, Nijmegen Institute for Cognition and Information, University of Nijmegen, PO Box 9104, 6500HE, The Netherlands.
Dutch Translation: Smits-Engelsman, B.C.M. (1998). *Movement Assessment Battery for Children: Nederlands handleiding.* Lisse: Swets en Zeitlinger.

Unpublished Theses

In addition to published studies, a number of unpublished theses include studies in which the *TOMI*/*Movement ABC* has been employed:

Barnett, A. (1992). *Manual competence in clumsy children*. PhD Thesis. Institute of Education, University of London. U.K.

Jongmans, M.J. (1993). *Perceptuo-motor competence in prematurely born children at school age: neurological and psychological aspects*. PhD Thesis. Institute of Education University of London. U.K.

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Wright, H.C. (1996). *The identification, assessment and management of children with developmental coordination disorder.* PhD Thesis. University of Leeds, U.K.

We intend to update this bibliography periodically and would therefore be grateful to have our attention drawn to any omissions as well as to new studies. Also welcome are any suggestions about how the documentation could be improved. These should be addressed to:

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London WC1H OAA, U.K.

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